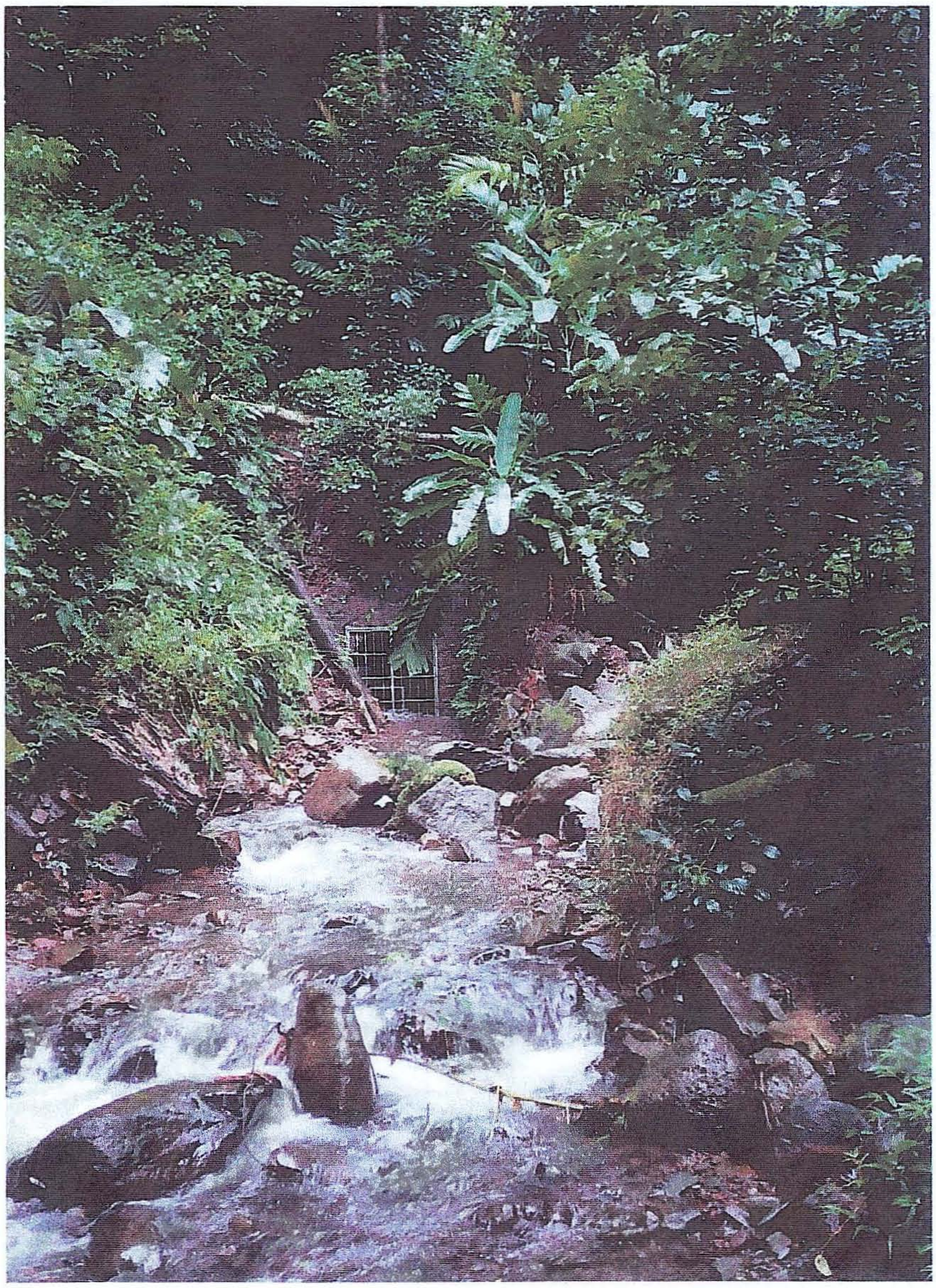
THE WAIWAI OF WAIĀHOLE AND WAIKĀNE:

The Construction and Operation Of the Waiāhole/Waikāne Water Ditch and Tunnel System

1900 to 2000



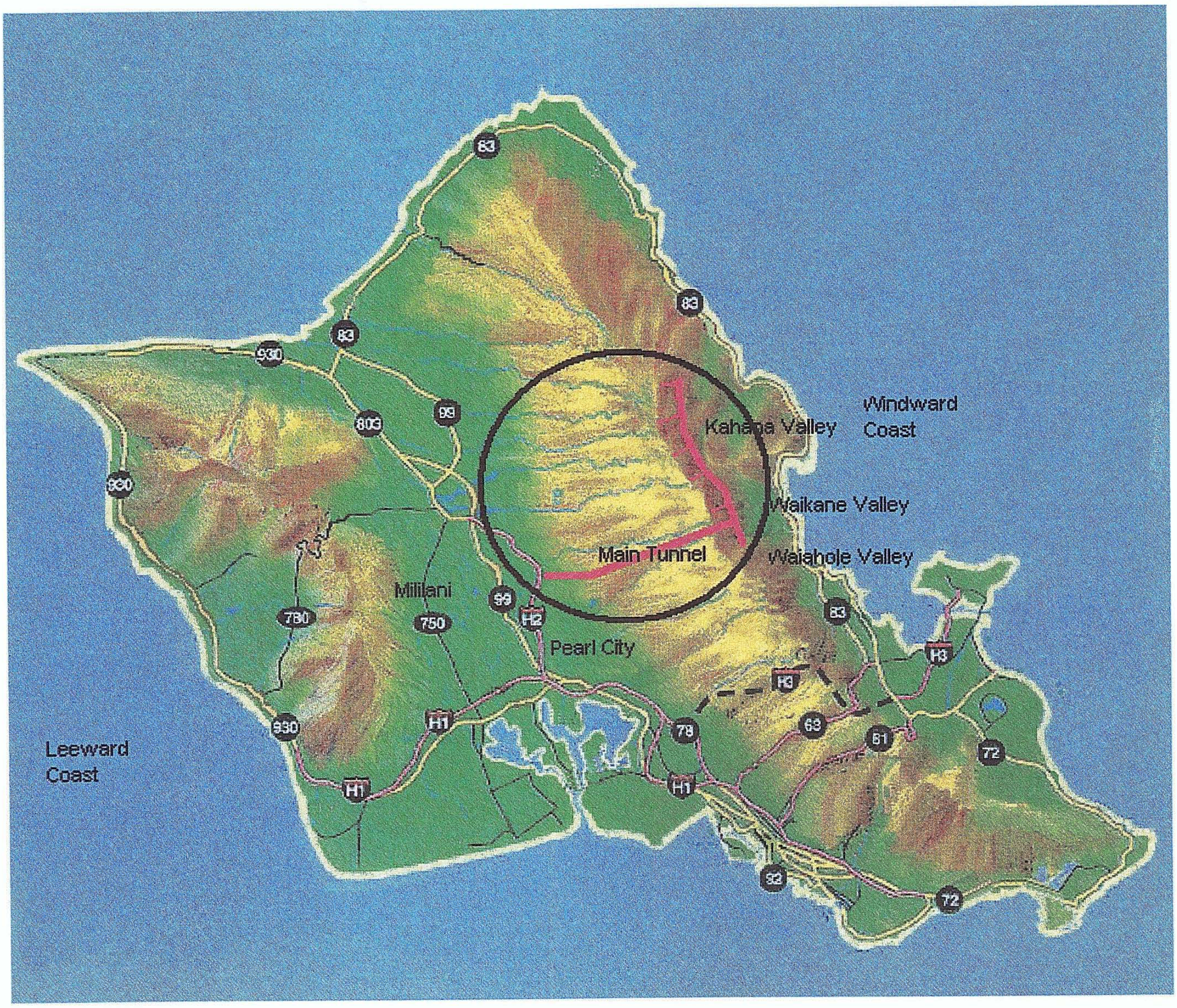
by

Dale E. Hood

May 2004

Island of Oahu

Heavy Pink line indicates area of study.



Detailed foldout maps are located at the end of the book.

THE WAIWAI OF WAIĀHOLE AND WAIKĀNE:

The Construction and Operation Of the Waiāhole/Waikāne Water Ditch and Tunnel System

1900 to 2000

MA Program
in
Pacific Island Studies

Plan B Paper

By

Dale E. Hood
Spring 2004

Committee Members

Dr. Terence Wesley-Smith, chairman
Dr. Karen Peacock
Dr. Michael Hamnett

Table of Contents

Acknowledgments

I am not sure of the appropriateness of an acknowledgment page for a Plan B paper; however, if allowed I should think it absolutely necessary to extend my "Mahalo nui loa" to those who gave freely their friendship and expertise to me.

It would have been so easy for people to say, "Sorry, busy, can't help you right now." However, once people saw my interest and perseverance, their doors opened to me. The kokua (assistance) that these individuals extended to me cannot be overstated; for without their help and encouragement this, paper might never have been written.

To Ms. Ann Marsteller, Librarian of the Hawaii Agriculture Research Center, I wish to extend my gratitude to her for taking the time to research her archives for anything which might apply to my project.

To Mr. Burt Hatton of The Estate of James Campbell who gave freely of his time and whose contacts made it possible for me to further my research.

To Mr. Alfredo Lee, Executive Director, Agribusiness Development Corporation, who made it possible for me to work with his staff in furthering my research and making it possible for me to tour the Waiāhole/Waikāne Tunnel System.

To Ms. Lynn Owan, Office Manager of the Waiāhole Water System, who allowed me access to her files of original documents which were retrieved from the Oahu Sugar Company fire. Ms. Owan was most gracious in allowing me to spend an entire day in her office copying those remaining files and pictures. Ms. Owan made it possible to have the only surviving maps from the construction of the tunnel to be duplicated. A copy of these maps is now available in the Map Collection of the Hamilton Library.

To Mr. Vernon Pico, Supervisor of the Waiāhole Water System who escorted me through the Waiāhole/Waikāne tunnels and ditches. The experience of seeing the tunnels first hand and to have the privilege of walking through them cannot be put into words. I will forever remember my first visit to these places. Mahalo nui loa for making it possible for me to take a trans-Ko'olau kayak trip through the tunnels.

To Mr. John Bautista who escorted me through the tunnels on the kayak. Your patience and kindness in answering all my questions as we traversed the mountain will never be forgotten.

To Mr. David Steele, my neighbor, who patiently read my drafts, and whose input I respected.

To Ms. Barbara Hotta, colleague and friend, who patiently stored all my files via email for backup and protection. Ms. Hotta's input and suggestion regarding the map of O'ahu was most appreciated.

To Mr. Michael Mauricio, author of several articles on the Waiahole Water System, I wish to say "Mahalo nui loa" for twice coming to my home and allowing me access to his research notes, files, and photographs.

To Ms. Carol Wilcox, author of *Sugar Water*, who invited me to her home and graciously answered my thousand questions and made copies of her personal notes for me to use.

To Dr. Terence Wesley-Smith, Dr. Karen Peacock, and Dr. Michael Hamnett, my committee members who gave me direction, encouragement and respect.

Most of all, Me ke aloha pumehana to my wife Teresa, who, for 35 years, stayed by my side and whose stoic strength I have relied on as I pursued my college degrees. Her help and support has made this journey not only possible but worthwhile.

Pictures Resources

During the course of my research I came across many photographs of the Waiāhole Tunnel project which I would love to include in this paper. The shear number of photographs in my collection makes it impossible for me to include them all in this paper; nonetheless, I have selected a few which are representative of my exciting research into the Waiāhole ditch and tunnel system.

The first group of photographs which you will see here are copies of the originals owned by the Agribusiness Development Corporation. These pictures are the only prints which survived the O'ahu Sugar Company fire, and they are extremely exceptional because they depict various stages of construction showing the many facets of the project. (99-106)

The second group of photographs comes from Mr. Michael Mauricio. His generosity in allowing me access to his archival material as well as his collection of photographs cannot be overstated. His collection of photographs is unique in that they show haole (Caucasian) visitors to the construction site. (107-111)

The third group of photographs are my own which I took during my two visits to the tunnels. Although these pictures are not unique, they are special to me because they document my visits to and through the tunnels. (112-118)

Preface

On Tuesday, March 23, 2004, staff members of the Agribusiness Development Corporation escorted me on a tour of the Waiāhole/Waikāne water ditch and tunnel system located on the Windward side of the Ko'olau mountains. It would be an understatement to say that I was overwhelmed by what I saw. Although I was expecting to see tunnels and ditches, I was surprised to learn that there are no ditches on the Windward side. Most of the water collection systems take place within "developmental" tunnels, and I was amazed to see that I could be standing only feet away from the entrance to one of these tunnels and not even realize it.

During this tour I was able to see firsthand how these tunnels were constructed and how it is that they collect water from the developmental tunnels and streams and divert these waters into the main transport tunnel. Once inside, it became apparent that these tunnels intersect each other at different levels for the purpose of transporting water to the leeward side of the island. What is hard to describe is the sense of awe one gets when seeing this system for the first time. These adits (or tunnel entrances) are located in remote areas which are surrounded by an immense forest. The first question that comes to my mind is, "How on earth did the engineers know where to dig, and how did they know what direction to go?"

The highlight of this day was made possible when I saw the entrance to the North portal. It was sad to see that this entrance is almost covered over with debris from fallen rocks and vegetation. (See pictures at the end of this paper) About 75 yards to the right of the North portal is the entrance to the drainage tunnel which was constructed for the purpose of removing millions of gallons of water from the main tunnel during its construction. From the entrance of this tunnel, we hiked in about 1700 feet to the end of this tunnel where old wooden stairs led us down to the intersection of the main tunnel. From this vantage point I was able to see for the first time the amount of water flowing towards the leeward side of the island. It is at this point that I discovered that I was standing directly under the crest of the Ko'olau mountains and that this is the border between Bishop Estate and State of Hawaii lands.

Following this tour, I made an enquiry into the possibility of taking a trip through the main tunnel and was pleased (actually, excited beyond words) to find out that they would accommodate me the following Tuesday morning. The big day finally arrived; after driving up to the main staging area, we entered the tunnels at "Intake 31." It was in this tunnel that a diversion gate was lifted which allowed for more water to flow through the main tunnel. After waiting a half-hour for the water level to rise, the two-man kayak was lowered into the frigid waters of the tunnel, and we climbed down a ladder into the rushing water. The

experience of feeling the power of the water against my legs was most exhilarating. I must confess I felt as though I was going to be swept off my feet and dumped head-first into the cold water; the scary thought of floating down the tunnel in the darkness and cold crossed my mind.

Mounting the kayak, we were soon off on what I can only describe as a trip of a lifetime. For the next two hours or so, we paddled and floated along on a rushing current of water which propelled us through the mountain. The lights on our hard hats were the only illumination; and, being the front passenger, it was my light which tried in vain to defeat the darkness ahead of us.

About an hour into our journey and just when it seemed as though the trip through the tunnel was becoming a little routine, my guide asked me to turn off my light. The reason for his request was immediately apparent when I saw ahead of us what looked like sunlight streaming into the tunnel. My curiosity as to the source of this sunlight was soon answered when, in about 10 minutes, we came upon a vertical shaft which extended above us about 50 feet to the surface (ridgeline) of the mountain in which we found ourselves. I was saddened to learn that sometime in the 1970s, a hiker had fallen through rotten boards covering this shaft and died from his injuries. The hole is now covered with a steel grate.

Further along in the tunnel, we came upon an adit (tunnel entrance or intake) which exited on the side of the mountain. The

original purpose of this adit was to divert water which was collected in ditches on the exterior of the mountain and to direct these waters into the main tunnel. After securing the kayak, we exited this shaft and came out on the side of a mountain somewhere above the Waiawa stream for I could hear what sounded like a large waterfall just below us. It was here that I had wished I had brought my GPS (Global Positioning System) receiver so that I could mark the spot on my map for future reference. From this tunnel entrance, we hiked out to a spot on the mountain to check the National Weather Service's rain gauge which requires monthly readings.

I would like to add that this diversion tunnel is absolutely impossible to locate from the exterior of the mountain and, if you did not know of its existence, you could never find it. At this point we were still several hundred feet above sea level and far from civilization. I believe that we were somewhere in the back of Waiawa valley.

Back in the tunnel we boarded our kayak and continued onto the South Portal. After first noticing the "light-at-the-end-of-the-tunnel," it took us another 10 – 15 minutes before we reached the exit some two and half hours since entering the tunnels on the windward side of the Koolau mountains. We exited the main tunnel in a small ravine where we concluded our trip by measuring the amount of water flowing out of the tunnel. The water from the tunnel crosses this small ravine and

enters back into the mountain traveling under the minimum security prison before finally exiting above the Mililani cemetery.

Earlier, I had learned that the trans-Koolau tunnel contributes water to the system in excess of 2 million gallons per day. What makes this little fact so interesting is that there are no obvious places in which to see this much water entering the tunnel. Sure, there are drips from the ceiling, some more than others, but nothing which would account for so much water.

I wish to explain that the interior of the tunnel does not follow a straight path. It makes several turns, first one way, and then the other. I could only imagine that the interior of the tunnel was following the curve of the ridgeline of the mountain above us. The realization of what those engineers did, almost a hundred years ago, without the aid of trucks, cars, four-wheel drives, airplanes, helicopters, and modern machinery, amazes me beyond all comprehension. In fact, my words do not do justice to what I saw and experienced.

The research for this project started three years ago in the Fall of 2001. Initially we (students) were asked to come up with an "idea" for a concept paper which, it was hoped, would eventually lead to a thesis or Plan B paper.

I remember coming up with two ideas. My first idea, or concept, was to retrace Captain Cook's voyage through the Hawaiian archipelago and somehow or someway try to recreate the navigational maps which he

and his crew produced. Although it was an interesting idea, hindsight makes it clear that this would have been an impossible task. The crew needed to accomplish something of this magnitude (not to mention the training) would have been prohibitively expensive, and this does not even take into account the cost of a boat, crew, and captain needed for a project of this magnitude.

My second idea (somewhat more doable) focused on a distant family member who was responsible for bringing my grandfather to the Hawaiian Islands. This relative is Jorgen Jorgensen, and it is he who is responsible for designing and building the Waiāhole/Waikāne water ditch and tunnel system which brought water from the windward side of the Ko'olau mountains to the leeward side of the island. Although it was my goal to write a biography of Jorgensen, I soon discovered that very little information existed about him.

Following on the heels of that idea, I changed the focus of my concept paper from the individual to the project itself. The construction of the Waiāhole/Waikāne tunnel is well documented and there are many sources from which to research. Unfortunately, none of these sources can be found in one document. My research into the construction of the Waiāhole Tunnel took me on a journey which started at Hamilton Library and culminated with a fantastic three mile trans-Ko'olau kayak trip from the North portal to the South portal.

My research also took me to places such as the State Archives Building, Mission Houses Museum, Hawai'i Agriculture Research Center, Waipahu Cultural Gardens, Elk's Club, Shriner's Club, Waiāhole Water System's Office, and The Estate of James Campbell. This journey of nearly 3 years (although financially expensive) has been an interesting one, and I am far richer for having done it. The kayak trip through the Ko'olau mountain was, without a doubt, an experience I will never forget.

Chapter I

Introduction

Early Hawaiians considered water not only as a natural resource which was used to feed their taro fields but also as something much more valuable. It is no coincidence then that the Hawaiians placed much value on this precious resource; it was so precious, in fact, that the very word for goods, property, assets, valuables, value, worth, wealth, importance, benefit, and estate is "waiwai" meaning, lots of water. The root word for waiwai is wai, which means water, specifically fresh, drinking water: the kind of water that is necessary to sustain life, water for the growing of crops and sustenance for man and beast. Gods were attached to the water and strict kapus were used to control its use.

With the arrival of the white man the kapu system was eventually overturned and valuable resources such as water were used by these newcomers to irrigate the fields of their new sugar plantations. As we will see, the taking (some would argue, the stealing) of this precious resource was disastrous for the native Hawaiians.

Starting with a historical perspective of the sugar industry in Hawai'i, this paper will address several serious issues which led to the downfall of the Hawaiian Monarchy and the rise to power of the haole (Caucasians) elite who took control of Hawai'i and handed it over to the Big Five corporations. As the sugar industry grew, technological changes

brought about newer methods of production, and chief among these changes was the development of access to water resources both ground water and surface runoff water.

This paper is not meant as a celebration of the construction of the Waiāhole/Waikāne water ditch system but rather as an informative work describing the climate of change in Hawai'i which gave rise to ambitious projects such as this. Neither is this paper going to be used as a vehicle to validate claims of ownership of water resources or justify who was right or wrong in making the decision to build this complex network of ditches and tunnels. The Waiāhole/Waikāne system of ditches and tunnels followed on-the-heels of similar projects that were built on Maui and the Big Island.

This paper is about the way in which the haole elite used their technical expertise to collect and transport millions of gallons of water through miles of tunnels and ditches from one side of the Koolau mountain range to the other. The "taking" of this resource was not without repercussions. Native Hawaiians, who, for centuries, used this water to irrigate their taro fields, called lo'i, found their streams drying up and their lo'i starving for water in which to grow their taro. Deprived of their water, Hawaiians eventually were dispossessed from their lands and homes, causing further decline in their population. Noel Kent, author of *Hawaii: Islands Under The Influence*, writes:

> "The ouster of the Hawaiian people from the land was an irreparable blow which doomed them to cultural debasement, economic destitution, and a third-rate status in their own homeland. It continued the policy of appropriating Hawaiian resources to further the ends of capitalist accumulation and had the ultimate effect of undermining, once and for all, the viability of the Hawaiian way."
>
> (Kent, 1983, 32)

The beginning of 1900 was a watershed moment in Hawaiian history. Queen Liliuokalani was overthrown; the Reciprocity treaty had been renewed. The Great Māhele of 1848 brought changes in land ownership by giving the kanaka maoli (full-blooded Hawaiian person) access to ownership of their land as well as ownership and land rights to outsiders. Below, Lilikalā Kame'eleihiwa gives her insight as to the meaning of the Great Māhele:

> "The culmination of changes in traditional Land tenure in Hawaii in 1848 is commonly known as the 'Great *Māhele*.' I refer to it simply as the '1848 Mahele' because it proved to be such a terrible disaster for the Hawaiian people, and the word 'great' has a connotation of superior. It was a tragic historical event, a turning point that had catastrophic negative consequences for Hawaiians. The Māhele transformed the traditional Land system form one of communal tenure to private ownership on the capitalist model. Whereas under the communal system all people had access to Land, which was administered by the Chiefs and cultivated by the commoners, the new model of private ownership required that both Chiefs and commoners claim and hold private title to their Land. Yet private title to Land was and is a concept entirely foreign to Polynesia."
>
> (Kamae'eleihiwa, 1992, 8-9)

More information can be found in Lilikalā Kame'eleihiwa's book, *Native Land and Foreign Desires.*

As we will see in the next chapter, technological changes were on the horizon: tracks were being laid on four islands to accommodate new railroads; wireless and cable communication systems were being installed; sailing ships had been replaced by steamships; and electric power plants provided new forms of energy which further transformed the islands.

The Waiāhole/Waikāne water ditch system was an engineering triumph unequaled in the Hawaiian Islands, and its construction has been a subject of controversy ever since its completion in 1918. It made some people wealthy beyond imagination while making others, usually native Hawaiians, poor beyond belief. The construction of this system of ditches and tunnels literally forced the inhabitants of the Waiāhole and Waikane valleys into starvation while providing untold wealth to the sugar planters on the Leeward side of the island.

Carol Wilcox, author of *Sugar Water*, writes: "The Waiahole Ditch was ambitious by any standard" (Wilcox, 1996, 98). The purpose of this ditch and tunnel system was to collect millions of gallons of water from the Windward side of O'ahu and move it through the Ko'olau mountain range and deposit this precious resource onto the dry and parched land in central Oahu. King Sugar, as it was later to be called, required millions and millions of gallons of water for its production. Central O'ahu had its own water resources, but these were deep underground,

too expensive to pump to the surface, especially in the quantities needed to grow sugar cane.

Haole elites who had invested in sugar during the mid-1800s and into the 1900s realized huge profits. More profit was to be realized when large holding companies were formed which provided technological support as well as capital for the expanding sugar plantations.

It is clear that as sugar continued its rise in dominance over the islands more and more land was needed in order to satisfy the demand of the growers. Each new acre of cultivated land required thousands of gallons of water which meant further demand on water resources. The problem was: growers needed more than just a few thousand gallons of water; they needed millions of gallons of water, everyday! In his book *Hawaii, Islands Under the Influence*, Noel Kent writes the following:

> "R.C. Wyllie, a planter and Hawaii's foreign minister from 1845 to 1865, outlined three ingredients for the commercial success of the sugar industry: 'Three fundamental elements essential to our progress are cheap land, cheap money and cheap labor.' The Mahele and new land policies delivered at least two of these."
>
> (Kent, 1983, 35)

Of course, one very important ingredient that is not mentioned in Kent's report is the need for large quantities of water. Without access to an abundant and cheap source of water, there can be no sugar. No sugar meant no profit. No profit meant no riches.

The turn of the century found Hawai'i firmly in control, not by a Monarchy but by the Big Five; Kent's words attest to this fact:

> "In no part of the United States is a single industry so predominant as the sugar industry is in Hawai'i . . . and directly or indirectly, all individuals in the Territory of Hawaii are ultimately dependent upon the sugar industry. The social, the economic and the political structure of the islands alike are built upon a foundation of sugar."
>
> (Kent, 1983, 74)

The sugar industry in Hawaii was the moving force behind all segments of life in Hawai'i. To this end, the sugar industry not only made money and controlled it, but it also spent enormous amounts of money to promote their agriculture activities on unlimited scales. To make more lands available for the growing of sugar cane, unlimited amounts of water had to be procured. The Waiāhole/Waikāne water ditch system was conceived and developed in order to transport millions of gallons of water from the Windward side of the Ko'olau mountain range to the arid fields of the Leeward side of the island.

The Waiāhole/Waikāne water ditch project began in 1913 when it was decided that more land on the dry Leeward side of the island could be used for sugar cultivation if a reliable source of water could be found with which to irrigate the cane. This abundant source of water was found in the Waiāhole/Waikāne valleys and all that was needed was a means of transporting that water from the Windward side of the island to the Leeward side.

By 1913, many water ditch projects throughout the islands had come to completion, and their success in the various locations proved that these ditches could increase sugar cultivation and, in return, create huge profits for their owners. For the Leeward side of O'ahu, all that was needed was water and lots of it. If millions more gallons of water could be secured, millions of dollars in profits would be the result.

Getting the water from the Windward side of the Ko'olau mountains to the leeward side would not only be an expensive process but, more importantly, it would be one of the engineering marvels of its time. So, in February of 1913, the most ambitious tunnel project yet undertaken in the Territory of Hawai'i was started.

By the time the project was completed in 1917, over 22 miles of tunnels and ditches were constructed for the purpose of transporting 125 million gallons per day from the Windward side to the Leeward side of O'ahu. Carol Wilcox writes:

> "The main tunnel, which traversed the Koolau Range, was 14,339 feet, or 2.7 miles--the longest transmountain tunnel in Hawaii until the construction of the Molokai Tunnel. . . . Because it passed under the crest of the mountain, where the dikes were the most frequent, it was by far the hardest tunnel to bore."
>
> (Wilcox, 1996, 99)

Additional information about dikes can be found on page 39.

Finally, this paper will step back and take a look at the historical significance of the construction of the Waiāhole/Waikāne water ditch

system and attempt to determine who gained from this construction and who lost. What did it mean for the sugar industry? What did it mean for the Hawaiians? The conclusion will take a close look at the contemporary issues which still trigger emotions to this day.

A good question to ask is, "What interest do I have in writing a paper about the Waiāhole/Waikāne water ditch system?" My interest in this particular water project stems from the knowledge that my grandfather's brother-in-law, Jorgen Jorgenson, was the contracting engineer who was hired to design and build the Waiāhole/Waikāne water ditch and tunnel. My grandfather and his family moved to the islands in 1918 at the request of Jorgen Jorgenson, who, through his connections and power, secured for them two choice homestead lots on the island of Kaua'i. My mother was only 10 years old when her family arrived in the islands and it has been my privilege to have spent many hours interviewing my mother in an attempt to learn as much as possible from her remembrances of her early years in Hawai'i.

My grandfather died shortly after their arrival in the islands and my mother's family ended up on the 'Ele'ele plantation where her brothers found jobs as lunas (overseers, usually Caucasian) in the fields and mills and her mother found work managing the boarding house for single men who worked as lunas on the plantation. In a small way, this paper is a testament to them and the years that they spent living and working on the plantations of Kaua'i and O'ahu.

Chapter II

Sugar as King: The Historical Perspective and Significance

Hawaiian Constitution and ownership of water resources.

In the book *Hawaii Pono* by Lawrence Fuchs, the concept of ownership of land and resources is described as somewhat feudal in Western terms. Fuchs states:

> "The Kings owned all the land and property and held power of life and death over their people. They subdivided land and gave it to many chiefs. The important chiefs held large estates, called ahupua'as, which usually extended from the shore to the mountains and were similar to the large estates of the nobility in England and on the Continent."
>
> (Fuchs, 1961, 6 & 7)

John H. Wise, a contributing author in *Ancient Hawaiian Civilization, A series of lectures delivered at The Kamehameha Schools* writes:

> ". . . ahupuaas varied greatly in size and shape. A typical ahupuaa was a long narrow strip (of land) running from the sea to the mountain. On the windward side of an island, a single valley often formed one ahupuaa."
>
> (Handy, 1965, 84)

In order to ensure the survival of the ahupua'a, the chief had to control the resources within his district. These limits or controls ranged from the fish in the ocean to the water in the streams. So important

were these controls that death was sometimes imposed on those who disobeyed their chief.

In a 2003 publication produced for the Honolulu Board of Water Supply titled, *Water for Life The History and Future of Water on O'ahu*, the author/s write:

> "Strict rules governed the use of water in ancient Hawai'i, and it was a grievous offense to waste or misuse the precious liquid. The ali'i ai moku (district chiefs) were the trustees of water and exercised control over it as an instrument of the gods."
>
> (Water for Life, 2003, unpaged)

The concept of "instrument of the gods" or "kapu" is crucial in our understanding of how the native Hawaiians viewed their culture. "The kapus gave the social system (of the Hawaiians) great stability, perpetuating the control of the kings, chiefs, and priests" (Fuchs, 1961, 6). This kapu or tapu system could be found throughout Polynesia and was one of the more difficult concepts for westerners to understand. As we will see later in this chapter, this view held by the Hawaiians was about to be changed forever, and, with it, the kanaka maoli (people) and the 'āina (land).

Prior to Western contact the indigenous people of Hawai'i enjoyed a rather robust and industrious lifestyle free from the pressures of the outside world. "The social system that the haoles found in Hawaii was feudal but not primitive. Though the Hawaiians had neither a written language nor iron implements, they were not Stone Age men" (Fuchs,

1961, 4). Eleanor C. Nordyke, author of *The Peopling of Hawai'i*, concurs with Fuchs when she writes the following:

> "Over a period of more than one thousand years, the early Polynesian inhabitants of Hawai'i developed a self-sustaining, distinctive culture. Despite the absence of a written language and the lack of natural resources for production of metal products, they created a subsistence economy in a cooperative society. . . they established a community of complex social, religious, and cultural practices."
>
> (Nordyke, 1989, 11-12)

Hawaiian irrigation systems prior to contact.

The growing of taro was absolutely essential to the native Hawaiian. Two basic types of taro were grown for consumption; dry-land and wet-land taro. The one most preferred was the wet-land taro and to grow it properly, large quantities of fresh, cool water was needed in order to fill the demand of the growing population. This water had to be diverted into fields or terraces called lo'i which were flooded and kept cool by the continuous flow of water. As the water left one field it was directed by irrigation ditches called 'auwai, into other fields insuring maximum use of the water.

"The 'auwai were continually repaired to prevent seepage and waste. Daily water distribution was overseen by a luna wai (water manager); farmers were allowed to use water as long as they kept their lo'i productive and helped to maintain streams and 'auwai" (Water for Life, 2003, unpaged). Fuchs states the following:

> "Polynesian ingenuity appeared in the Hawaiian system of irrigation, used especially in the production of taro. The system was praised by the English explorer George Vancouver as surpassing anything of the kind he had ever seen. Yams, sugar cane, and breadfruit were commonly grown and eaten. The Hawaiians also ate a variety of fish, domestic goose, owl, and wild birds. For meat—though the commoners did not get much of it—the Islanders relied on small dogs and pigs."
>
> (Fuchs, 1961, 5)

On the Island of Kaua'i, the ingenuity of the Hawaiians can be seen in an irrigation ditch which was carved out of stone on the side of a mountain. This ditch stands as a solemn testament to the engineering abilities of the native Hawaiians who understood the importance of water delivery systems. "When Captain James Cook came ashore at Waimea, Kauai, in 1778, he saw Hawaiians using extensive and sophisticated irrigation systems, mainly to cultivate taro. They were also growing other crops, including sugarcane" (Wilcox, 1996, 1).

<u>The colonization of Hawai'i and the fall of the Hawaiian Kingdom.</u>

Contact with the western world in the early 1800s changed everything for the Hawaiians. The first of these changes brought about the unification of the islands under one King. Kamehameha I, with the help of westerners and their firepower, conquered the islands and for the first time united the Hawaiian Islands under one king.

Further changes were brought about by the sandalwood traders and whalers who introduced a culture radically different from the one

which the Hawaiians knew. These changes were exacerbated still further when, a short time later, the missionaries and settlers arrived bringing even more radical changes when they introduced new social reforms which included the ideals of Christianity, capitalism, and private property. This introduced culture eventually led to the abandonment of the centuries old kapu system which the chiefs had used to rule the commoners.

More changes were brought about by the newcomers when they infected the native population with western diseases. These changes affected the Hawaiians in unimaginable ways. The population declined sharply, further eroding the native culture which barely survived this onslaught. Estimates of this decline vary from author to author. Nordyke states:

> "The high mortality level among Hawaiians was a basic factor in depopulation. Because the islanders possessed no natural immunity to the diseases of foreigners, they became victims of contagious illnesses, such as measles, whooping cough, and mumps, which were rarely fatal to Europeans and Asians. . . In the two hundred years since the entrance of foreigners to the land settled by ancient Polynesians, the race known as Hawaiian has been almost completely depleted by high mortality, low fertility, out- migration, and intermarriage."
>
> (Nordyke, 1989, 22, 27)

Further discussion about population figures can be found in *Before the Horror The Population of Hawai'i on the Eve of Western Contact,* by David E. Stannard.

In the book, *Islands and Beaches Discourse on a silent land: Marquesas 1774-1880,* Greg Dening addresses how changes in native culture are brought about by death. Those who have the knowledge of cultural practices take that knowledge with them to the grave when they die. "The past and knowledge of it had been leached from the land by death and change" (Dening, 1980, 2). This is precisely what happened in Hawai'i. The population declined sharply and the cultural knowledge base collapsed.

The growth of the sugar industry in Hawai'i precipitated the final decline of the Hawaiian Monarchy. By the mid-1800s the sugar industry had established itself as the leading economic engine and sugar planters began to push for land reforms in order to protect their investments. These demands also lead to the decline of traditional land and water rights in the quest to grow more and more sugar. Lawrence Fuchs writes in *Hawaii Pono*:

> "After the Great Mahele, the expansion of haole investments in land, sugar, and other enterprises was followed by haole demands for even greater political influence, because the continued importation of labor and a favorable reciprocity treaty with the United States depended upon the approval of the government in Honolulu."
>
> (Fuchs, 1961, 25)

Thousands of immigrants from around the world came to the Islands to work on the plantations, bringing with them more changes. "In the 1800s, nothing could resist the winds of change: Hawai'i's

religious, political, economic and social systems were transformed in the wake of contact with the outside world" (Water for Life, 2003, unpaged).

How the water was taken from the indigenous people.

Change had come to the Hawaiian Islands. By mid-1800 the Hawaiians were faced with an ever increasing loss of control over their destiny. The kapu system was abandoned and traditional land and water rights had been abolished. The newcomers demand for water to feed their growing industries lead to the installation of the first water pipe in 1848. From that moment on, "water engineering became the order of the day on O'ahu" (Water for Life, 2003, unpaged).

The loss of southern sugar during the American Civil War and the discovery of gold in California created a huge demand for Hawaiian sugar. By 1878 there were 46 plantations needing thousands of gallons of water to irrigate their sugar fields. On O'ahu, 40,000 acres of land were under cultivation which meant that 400 million gallons of water per day had to be diverted in order to satisfy this thirsty plant. (Wilcox, 1996, 2-5).

The obvious source for this water would be the final nail that would seal the fate of the Hawaiians. Water from the ahupua'as were diverted from streams which for centuries, had fed the lo'i of the native population. The ramifications of diverting the water caused devastation on the remaining kanaka maoli. Taking of the water from the lo'i caused

a decline in the production of taro, the staple crop of the Hawaiian people.

Carol Wilcox addresses this situation in *Sugar Water Hawaii's Plantation Ditches*, when she writes, "By the time of sugar's ascendancy, when the large water projects were diverting water away from the valleys and their villages, these villages did not have the population, organization, or will to protest" (Wilcox, 1996, 31). The stage was set for sugar to dominate all aspects of life in Hawaii.

Who served King Sugar?

The growth of the sugar industry in Hawai'i was meteoric in its scope, and the changes brought on by its success in the mid-1800s led to the signing of the Reciprocity Agreement in 1876, between the Hawaiian Government and the United States of America which allowed sugar to be exported to the United States duty free. The renewal of this treaty in 1886 gave the United States Navy a long term lease to what would later be known as Pearl Harbor. Lawrence Fuchs writes:

> "The effects of reciprocity were tremendous. . . Sugar reached out everywhere, surging into rice lands, coffee lands, taro patches, and small Hawaiian kuleanas. The two most significant results of the expansion of the sugar industry were the increasing political and financial influences of a small number of haoles and the importation of thousands of Oriental peasants to work on the plantations."
>
> (Fuchs, 1961, 21)

King Sugar was also served by the industrial revolution. Carol Wilcox states that, "Within a few decades the world saw remarkable adaptations of steam and electric power, development of machinery and heavy equipment, scientific and technical innovations" (Wilcox, 1996, 1). These advances in technology fueled the growth of the sugar industry and, for the first time, the mass production of sugar.

For King Sugar to flourish it demanded thousands of acres of land, copious amounts of sunshine, tens of thousands of laborers from overseas and most importantly, it demanded water. Water was an integral part of every aspect of growing sugar; power, transportation, production, and growing of sugar all depended on water. Millions of gallons of water were needed everyday.

The Big Five and who it was that King Sugar served.

King Sugar served the haole elite, and it served those who risked their own capital and labor, but most of all, it served the "Big Five." Carol Wilcox sums up the role of the Big Five:

> "By 1900, about 89 percent of all plantation production was controlled by sugar factors that had gained power through the control and management of marketing. These agencies eventually evolved into the Big Five: Alexander & Baldwin, Castle & Cooke, Theo Davies, Amfac, and C. Brewer & Company. These factors controlled the sugar industry from field to table. They owned or controlled the land, plantations, water, power, production, mills, labor, transportation, refineries. They controlled banks, insurance, marketing, and, some would argue, the local government."
> (Wilcox, 1996, 20)

The Big Five dominated all aspects of life in Hawaii. Through "interlocking directorships" the Big Five's tentacles reached into government easily passing laws which benefited the sugar and pineapple growers. The Big Five's control over the islands insured both its survival and its growth as well as huge profits which served the haole elite.

Who King Sugar did not serve.

King Sugar did not serve the native Hawaiian population. Although it can be argued that the Hawaiian Kingdom profited from its association with the sugar growers, it can also be argued that the powerful sugar industry led to the overthrow of the Monarchy and set the stage for the Provisional Government, and, later, the annexation of the Hawaiian Islands by the United States.

Importation of laborers to work on the plantations caused further decline in the Hawaiian population due to newer introduced diseases. In *Shoal of Time A History of the Hawaiian Islands*, Gavin Daws writes, "To add to the Hawaiians' miseries a new and appalling scourge was at work amongst them---leprosy. The natives called it mai pake, Chinese disease, though no one really knew who brought it to the islands" (Daws, 1968, 209). The Hawaiian population continued its decline, the Monarchy had been taken from its people and immigrants from around the world were

flooding the shores of Hawaii transforming the islands into a new world unfit for the native people.

The expansion of the sugar industries.

The Great Māhele had "severed the Hawaiians from the land that had been the basis of their subsistence" (Kent 31). The Reciprocity Treaty with the United States further exacerbated the alienation of the Hawaiians disenfranchising them from their land. As Rogers states, "In 1893, American businessmen in Honolulu, eager to have Hawai'i a part of the United States, overthrew the last of the Hawaiian monarchs, Queen Liliuokalani" (Rogers, 1995, 108). The fall of the monarchy basically sealed the fate of the Hawaiians and ensured forever the rise of the haole elite and eventual control of the Hawaiian Islands to outsiders.

With the Monarchy dispossessed, the sugar industry had free reign to expand into every corner of the islands. From the Hamakua coast on the Big Island to the fringes of Kaua'i, sugar plantations sprang up in ever increasing numbers taking more land away from the kanaka maoli. More importantly, these plantations took away the waiwai (valuable water) which was essential for the survival of the Hawaiian people.

The political economy.

It is important to present a few numbers here in order to appreciate the growth of sugar and the impact that it had on the

economy. By 1920 this growth in sugar production was generating over $120 million annually.

Annual Production in Pounds of Sugar

1890	1900	1910	1932
250 million	500 million	1 billion	2 billion

(Wilcox, 1996, 20)

In *Sugar Islands The 165-Year Story of Sugar in Hawai'i*, William Dorrance gives the reader an insight as to the reasons behind this phenomenal growth:

> "In the last half of the nineteenth century, Hawai'i sugar planters adopted a scientific approach to cultivation. Vulnerability to erratic rainfall was eliminated with irrigation . . . and the cost of harvesting and transporting cane to the mill were studied. Fluming the harvested cane to some mills was cost-competitive. . . ."
>
> (Dorrance, 2000, 4 & 5)

These scientific methods covered all aspects of growing sugar and maximizing profits. Irrigation methods topped this expansion and by 1920 over 137,000 acres of sugar was being irrigated from waters diverted from streams and valleys, another 112,000 acres were being irrigated with ground water pumped to the service by steam-driven pumps. To access this precious resource the planters built a massive web of ditches and tunnels to divert these streams. "The sugar industry

diverted a lot of water. On Oahu, the Waiahole Tunnel delivered an average of 30 million gallons a day . . . ." (Wilcox, 1996, 5).

Kent also writes, "So great were the profits that all problems of capital scarcity disappeared. The development of the Hawaiian sugar industry after 1875 was largely through capital of its own creation" (Kent, 1983, 49). Some of this capital was used to construct massive water projects which eventually paid for themselves many times over.

By 1900 other major works were taking place on the islands. "Over, the years, common carrier railroads were built on all four of the major sugar islands" (Dorrance, 2000, 165). By 1905, a radio wireless link was established between the islands allowing managers on O'ahu to communicate with their plantations providing tighter control of operations. Inter-island steamship lines provided quicker transportation of people, goods and product between the islands. Hawai'i was experiencing rapid changes fueled by the need to further increase yields and profits for the sugar industry.

Chapter III

Historical Overview of Waiāhole/Waikāne

My primary sources for understanding land utilization in Waiāhole/Waikāne come from two articles found in the Hamilton Library, Hawaiian Collection. The first is an article titled *The Archaeology of Koolau-Poko, O'ahu, from the ahupua'a of Waiahole to the ahupua'a of Waikane* by P. Bion Griffin and Dorothy Pyle; the second source is an article titled *The Chinese on Windward Oahu: Waiahole, Waikane and Hakipuu* by Lum Pui Young.

The two articles provide a wealth of information about the utilization of the Waiāhole/Waikāne area and the status of occupation prior to the construction of the Waiāhole/Waikāne water ditch system. Although the archaeology report is comprehensive in nature, this paper will focus only on the habitation information provided in this report. Griffin and Pyle state:

> "The land of Waiahole-Waikane, while covering considerable area, is very little known to most persons on Oahu and in Hawaii. It is conveniently lumped together with several other ahupua'a into 'Kaneohe Bay' and so loses its identity. This non-identity made it a bit difficult to find specific information on the Waiahole-Waikane area."
>
> (Griffin, 1974, 8)

It is interesting to note that Young writes a similar description when he lumps the three areas of Waiāhole, Waikāne, and Hakipuu

together into one district: "The three areas of Waiahole, Waikane and Hakipuu were often spoken of as one region or community" (Young, 1975, 1). Although this area may have been considered as one large area, it was nonetheless made up of several large valleys fed with several sizable streams running back into the valley.

Historically speaking, the Waiāhole area was populated by native Hawaiians and used for extensive taro production. "So it would seem that in traditional (pre-contact) times, both Waiahole and Waikane ahupua'a were used for intensive agricultural purposes" (Griffin, 1974, 10).

The Great Māhele of 1848 brought about significant changes to the Hawaiian Islands, and it is not the purpose of this paper to go into a long explanation of its importance. It should suffice to say that the Māhele was disastrous to the Hawaiian people, and more land ownership eventually reverted to others not native to the 'āina (land).

By the mid-1800s, the Hawaiian population was in a significant decline brought about by introduced diseases and social changes unfamiliar to the native Hawaiians. It is interesting to note that Griffin and Pyle attribute the decline in the production of taro to the decline in native Hawaiians rather than the decline in taro production contributing to the further decline in the Hawaiian population. This eventual loss of taro production resulted in taro lo'i being given up for rice production. Griffin writes:

> "Almost all the taro producing areas of Windward Oahu were converted to rice production between 1870 and 1900. At first, Hawaiians and some haoles cultivated rice, but gradually Chinese leased lands and went into production. They were the most successful rice farmers and soon were producing a surplus that could be exported to California."
>
> (Griffin, 1974, 11)

By the turn of the century, 1900, the Waiāhole/Waikāne district was witness to substantial changes in tenant farming, and many Chinese families were living in this area displacing many Hawaiians. What is also clear is that some of the Chinese men were marring Hawaiian women and making Hawaii their new home with no thought of returning to China. Young states:

> "During the years mentioned, there were at one time, as many Chinese as native Hawaiians living in this region. Only a small number of other nationalities lived there. It was certain that the Chinese were farming rice in this region long before 1906."
>
> (Young, 1975,1)

Young informs his readers that Waiāhole was under 250 acres of rice cultivation, Waikāne under 300 acres of rice cultivation, and Hakipu'u having the fewest acres under cultivation and having the fewest Chinese. Young further states that it was plant disease that brought an end to this area's cultivation and not the construction of the Waiahole/Waikane water ditch system as had been thought previously. Young writes:

> "The Chinese began moving from the region in 1913, mainly, because it was no longer profitable to grow rice. Also, a

> fungus called 'smut' appeared about this time that caused the grains to grow into a ball which resembled a clump of dried mud. This hastened the abandonment of rice growing. It was also true in other parts of the islands."
>
> (Young, 1975, 5)

Young goes on the to say that by 1925 the Chinese had moved out of the Waiāhole/Waikāne region and that only small tenant farmers continued to make a living growing various crops. One of the unfortunate ramifications of this change from taro farming to rice cultivation was the eventual transfer of land ownership due to the changes made to the landscape. Griffin states the following:

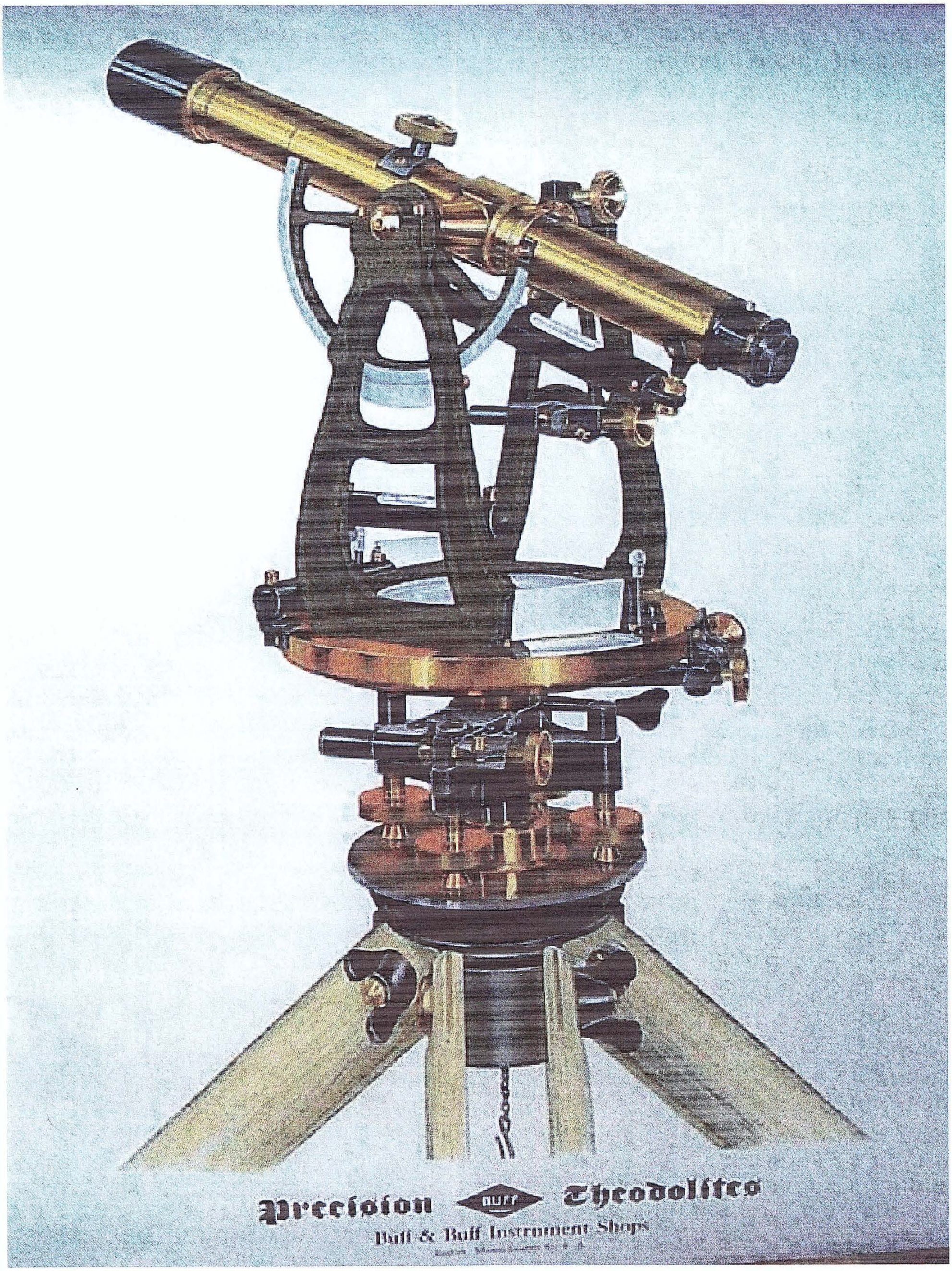
> "After 20 to 40 years of intensive cultivation in either rice or sugar, the natural land marks disappeared. New irrigation ditches were dug, trees cut, streams diverted, etc. The Hawaiians who wished to return to their ancestral lands, in many cases, could not identify the land any longer and so lost their claims. The land reverted to the government."
>
> (Griffin, 1974, 12)

Further decline in this region was brought about by the decreased demand for rice from the Waiāhole/Waikāne district. By 1910, this area was mostly abandoned and production was reduced to tenant framing. Lincoln McCandless, along with his brothers, had a large financial interest in the Oahu Sugar Company and foresaw the need for water in the Leeward district. He was able to purchase large tracts of the Waiahole/Waikane land from the government for use as grazing land as well as leases for tenant farmers. Young confirms this information by

stating: "Fields were rented or acquired by share-cropping" (Young, 1975, 1).

McCandless was also aware of the value of the water which flowed in this district, and in 1911 the Waiāhole Water Company was formed to carry through the plans to build a complex system of tunnels and ditches to transport water through the Koolau mountains to the dry region of Leeward Oahu. Work on the tunnel began in 1913 and opened in May of 1916 delivering millions of gallons of water daily to the Oahu Sugar Company.

Before closing this chapter it should be stated that some of the people living in the Waiāhole/Waikāne district were not without concerns regarding the newly proposed ditch system. In a letter written to the Territorial Governor dated October 26, 1912, and October 29, 1912, H. Harrison, a farmer, appealed for more information regarding the proposed use of water for the ditch system and inquired as to the effect this water diversion system would have on his crops. The Governor, Walter Frear, replied that water was to be taken from the upper levels only and that this diversion should not create a problem for those users at lower elevations. There is some mention of rice and taro patches but no data is given as to the size or acreage of these patches. The Governor concluded with: "I do not think you have any cause for worry" (Environment Hawai'i, vol. 5, no. 4, Oct 94).


Precision
Theodolites
Buff & Buff Instrument Shops

Chapter IV

Construction of the Tunnel and Ditch System

Introduction

In the larger context of the development and construction of the Waiāhole/Waikāne Water ditch and tunnel system, there are several key players who stand out above the others. Two of these key figures are H.K. Bishop and Jorgen Jorgensen, both civil engineers and both qualified to take on one of the most ambitious civil projects that was to be undertaken in Hawai'i. Although it was Bishop who started the construction of the tunnel, it was Jorgensen who replaced him and saw the tunnel through to its completion. A biography of Jorgen Jorgensen can be found in Appendix 3.

Many records which might have facilitated this paper were apparently lost in an office fire which was maliciously set on April 1st, 1999. These records were pertinent to the construction of the Waiāhole/Waikāne water ditch system and have been lost forever. It is also a sad note that many eyewitness accounts of the Japanese attack on Pearl Harbor were also lost in this fire. See Appendix 9 for further details about the fire.

To prevent the story of the construction of the Waiāhole/Waikāne water ditch system from being bogged down in too much detail, I have taken the liberty to place many of the specifications in Appendix 1.

Motivation for building the tunnel

Founded in 1897, the Oahu Sugar Company came into existence when large quantities of ground water were discovered in what is now called the Pearl Harbor Aquifer. This unlimited supply of water made it possible to irrigate the parched lands of Central and Leeward O'ahu, thus making Oahu Sugar Company a prosperous company. Michael Mauricio, author of *Sugar Legacy*, writes:

> "Because of the high elevation of their fields, the company had to dig many wells, some of them nearly 400 ft. deep. Water from Waiawa and Waikele streams were also used, but along with the well water, these had to be pumped up to the plateau, resulting in very high fuel expenses."
>
> (Mauricio, 1986, 4)

As Oahu Sugar Plantation grew, so did its desire to grow more and more sugarcane at higher and higher elevations. The need for greater quantities of water was a factor, but the water needed to be delivered at lower cost to the growers. This problem was first addressed in a Board of Directors meeting dated April, 29, 1905:

> "Mr. Maloney stated he thought it would be advisable to fully investigate the Koolau mountain range, as an enormous quantity of water there, which was now going to sea, might be diverted to the plantation; that as far as preliminary survey showed, in order to get the whole amount of water there would be required about 25,000 (feet) of tunneling, but that it might be possible to intercept the water nearer and if not all the water, at least a great quantity could thus be obtained, and that as this work would take at least 5 years, it was up to the Directors to decide whether they would favor such a plan and lay aside every year a certain sum for that

purpose, say $5,000 for the first year, $15,000 the next and so on."

(Mauricio, 1986, 4)

On January 30, 1913, E. K. Bull, Manager of the Oahu Sugar Co., Ltd., wrote in a Special Report titled *Water Development:*

"What the development of this irrigation project means to this plantation, and what effect it will have on our future crops, when this water reaches our fields, and an additional area of 3,000 acres of the choicest new land, has been brought under cultivation, is hardly necessary to comment upon; it is sufficient to state, that it is hardly possible to overestimate the value and importance of this water development, and that with it assured we may look to the future with confidence."

(Bull, Dec. 1912, 15)

Michael Mauricio sums it up best when he writes:

"Thus the seed was planted over eighty years ago. From it sprang one of Hawaii's most ambitious, if not the greatest, engineering feat: the digging of the Waiahole Tunnel. Designed to draw water from windward streams to irrigate the cane fields in Waipahu, the Waiahole project was acclaimed a marvel of engineering at its completion in 1916. Its eleven miles of tunnels pierce the Koolau range from Kahana to Waiahole and the addition of siphons and ditches stretch the entire system out to approximately 27 miles in length."

(Mauricio, 1986, 4)

General Plan

Because of the high cost of pumping water to the higher elevations, alternate means of delivering "the abundant and pure mountain surface waters from the windward side was developed" (Larrison, 1916, 81).

In an article titled *The Waiahole Tunnel Project,* G. K. Larrison, Superintendent of Hydrography wrote in the Hawaiian Forester and Agriculturist:

> "The plan decided upon was to gather up the mountain streams along the windward side from Waiahole to the Kahana valleys and to bring these via a long tunnel through the mountain range to a point where the water could be delivered to the Oahu plantation fields. It was planned not only to use the pure mountain water to mix with and rotate with the pumped water which could still be profitably pumped to serve the low lying fields and to eliminate the necessity of costly pumping to the high level fields, but also to bring under cultivation an additional area of about 3800 acres above the old fields."
>
> (Larrison, 1916, 81)

L.H. Herschler, author of *Fifty Years of Water Service,* writes that:

> "Waiahole water is particularly valuable to Oahu Sugar Company because it irrigates the higher cane lands, thus reducing plantation pumping costs, and much of the Waiahole water, on the order of one-third to one-half, percolates to the basal water table, providing a 'sweetening' effect to that somewhat brackish body of water."
>
> (Herschler, 1966, 4)

Surface Water Supply

In reference to the Waiāhole/Waikāne water ditch and tunnel, it is necessary to understand the importance of ground water flow on Oahu. One of the considerations in selecting the Waiāhole, Waikāne, and Kahana valleys as a source of water for the sugar fields of Leeward O'ahu

was the amount of water that flows through this region during periods when there is little or no rainfall.

Studies made of the Waiāhole, Waikāne, Kahana, and Punalu'u valleys determined the existence of a continuous flow of water. Larrison states:

> "None of the other streams on Oahu have discharges during dry weather in excess of three million gallons daily at elevations of five hundred feet or more above sea level. The Kahana stream has probably the greatest low water flow, while the low flows of the Waiahole and Punaluu streams are nearly as large. The Waikane steam is much smaller, but as it lies between the Waiahole and Kahana, its comparatively small flow is of considerable importance in augmenting the flow of the three larger streams. The flood discharges of all of these streams are very high and of much more frequent occurrence than on the leeward side of the island."
>
> (Larrison, 1916, 82)

It was also determined that there was a considerable water flow on the leeward side of the Koolau mountains; but, due to seepage, this water ended up percolating into the ground. Larrison continues:

> "On account of topographic and geologic conditions, however, the percentage of surface run-off to rainfall on the windward side is much greater than on the leeward side. It is estimated that at least fifty per cent of the rainfall on the leeward side becomes ground water which supplies the various and separate artesian supplies of the leeward valleys."
>
> (Larrison, 1916, 82)

"In 1905, Oahu Sugar Company hired engineer Jorgen Jorgensen to explore the possibility of bringing that windward water to Ewa. After several surveys and feasibility studies, the Waiahole Ditch plan . . .

based on Jorgensen's report was adopted by the directors on 19 August 1912" (Wilcox, 1996, 98)

Water Rights

The importance of securing water rights to the streams of Waiāhole, Waikāne and Kahana valleys cannot be overstated; for without these rights, the tunnel could never be built. E. K. Bull, Manager, Oahu Sugar Co., wrote:

> "The most important transaction consummated by this Company during the past year, was the acquirement of all the water right of the Waiahole, Waikane, Waianu and Kahana streams, on the Koolau side of this island, together with all the necessary right of way for tunnels and ditches through which it is intended to convey the water from these streams, to the lands of this Company. The organization of the Waiahole Water Company, for the purpose of developing these water sources, was recently completed, and work on the proposed aqueduct will soon be commenced, under the direction and supervision of Mr. H. K. Bishop, C. E., who has been engaged as Engineer in charge."
>
> (Bull, Dec. 1912)

Several important events in the history of Hawaii consummated the acquisition of the water rights to the Waiāhole, Waikāne and Kahana valleys. Chief among these events was the Great Māhele of 1848 which brought about changes in land tenure, eventually dispossessing the native population of their titles to the land. Hawaiians wishing to claim their land in the Waiāhole, Waikāne area were unable to identify the land in which they lived due to the changes made in the landscape by the

Chinese rice growers. These lands reverted back to the government which later became "a windfall for a haole entrepreneur named Lincoln McCandless" (Griffen 1974, 12). McCandless took advantage of this situation and bought up large tracks of land which he used for grazing. McCandless, who had a large interest in the Oahu Sugar Co., was also an expert on water sources and realized the potential use of the water from this area to irrigate the dry fields of the leeward side of the island.

Griffin writes, "Lincoln McCandless sold the water rights in upper Waiahole-Waikane to Oahu Sugar company for $250,000.00 but he retained the water rights below 600 feet elevation" (Griffen, 1974, 12).

Organization

Lynn Owan, of the Waiahole Water System, allowed me access to their few remaining files which document the beginning of the tunnel and ditch system. These are the only files which remained from a fire in April of 1999 which destroyed most of the archival material. A spokesman for Amfac/JMB Hawaii's real estate division said "many of the lost pictures and papers recorded the history of the Waiahole Irrigation Co. Some of the documents dated from the 1900s" (Ishikawa, April, 2, 1999). In one of these documents, drawn up by H. K. Bishop, chief engineer, I discovered the original organizational chart used during the construction of the Waiahole ditch and tunnel system. See Appendix 6 for the Organization Chart.

Charles Kluegel, author of *Engineering Features of the Waiahole Water Co.*, gives us his assessment of the organization when he writes:

> "The office of the Chief Engineer was located in Honolulu, where all plans were drawn, all maps were made, and records kept. The purchasing of material and the accounting were also done at the main office. The force in this office consisted of an Assistant Engineer, whose work was chiefly on plans and in preparing designs under the direction of the Chief Engineer; draughtsmen, clerks, and stenographer. Reporting to the Chief Engineer were two Division Engineers—one located at each portal of the main tunnel, each Division Engineer having two parties in the field, each party consisting of a chief of party, transitman, and rodman, and each division office had the services of a draughtsman for plotting up the notes and recording the data brought in by the field parties, all data being sent in to the main office as soon as checked and worked up."
>
> (Kluegel, 1916, 9-10)

Laborers

Although the tunnel and ditch system was conceived by haole engineers and the money to carry the construction through to its completion was fronted by organizations owned by the haole elite, it is clear from the research that everyone agrees on one thing: the bulk of the manual labor was carried on by Japanese laborers who were experienced tunnel and ditch builders. Carol Wilcox writes:

> "Starting in 1885 and throughout the major ditch building period, Japanese workers made up the majority of the ditch building labor force. Working on the ditches provided advancement opportunities for independent workers, especially those skilled in explosives, mechanics, transportation, or supervision. Over the years a skilled workforce developed and was in keen demand."
>
> (Wilcox, 1996, 52)

Michael Mauricio concurs with Wilcox when he writes:

> "Many of the laborers were Japanese, hardened tunnelmen, coming off jobs on the Hawaii Consolidated/Hilo Railroad and Kohala Ditch projects on the Big Island. Many of them worked with sub-contractors, being promised incentive wages for every day the work was on schedule."
>
> (Mauricio, 1986, 4)

Although there were Chinese males working on the project, Lum Pui Young writes that:

> ". . . contingents of 50 to 60 Chinese males . . . were used to build the railroad bed and trails from the seashore to the tunnel site. None of the Chinese did any tunneling. The Japanese did it all."
>
> (Young, 1975, 3)

Further credit is given to the Japanese men when Herschler reiterates what others have said:

> "The construction of these tunnels, siphons, and lined ditches was not easy—it took men of fortitude, determination, and a willingness to put in long hours of hard work under difficult living and working conditions . . . Tunneling was especially difficult under the prevailing wet and cold conditions."
>
> (Herschler, 1966, 3)

One final acclaim concerning the Japanese laborers is made by Kluegel:

> "Special tribute should be paid to the Japanese tunnel men without whom the excellent progress made on the tunnel would have been impossible. These 'professional' tunnel men, as they call themselves, prefer this work to any other, and they apparently take delight in the hardships incident to the work, the exposure to the cold water, and the risk in handling explosives. They were on the job all the time and

> never failed to deliver the goods in situations in which white men or native Hawaiians would have been physically impossible. Most of the drilling and mucking was done by these tunnel men as sub-contractors—a bonus being given for rapid work, which sharpened their interest and never failed to give results."
>
> (Kluegel, 1916, 20)

The amount of time that the Japanese laborers spent in the tunnels was modified over time in order to reduce the toll taken on the workers due to exposure to cold water. Three shifts of 8 hours each was changed to 4 shifts of 6 hours in a 24 hour period. This change was found to be satisfactory to the men.

The construction of the tunnel and ditch system was not without accidents which resulted in serious injury and death. Ten men were injured when the train leading to the tunnel entrance was wrecked. Wilcox writes:

> "In December, Jorgensen reported that 'a series of accidents resulting in four deaths of japanese laborers were accountered (*sic*) during the past month, all owing to carelessness on the part of the unfortunate in handling explosives. They were all men of at least 10 years experience in this kind of work and had been repeatedly warned to be cautious.'"
>
> (Wilcox, 1996, 102-103)

Initially, the camps used by the laborers were hastily constructed which led to unsanitary conditions and a brief outbreak of typhoid fever. Following the outbreak, "sanitary conveniences were built to comply with

the requirements of the Board of Health. No serious sickness, such as typhoid fever, gave any trouble" (Kluegel, 1916, 10).

Railroad

The importance of establishing a railroad at each portal was paramount to the success of the operation. "It was of importance that bases of supplies be established at each portal, so all possible speed was made in constructing the railway from Waikane landing to the North portal and the rail way from Pump 6 at Oahu Plantation to the South portal" (Kluegel, 1916, 10).

In the progress report dated February 1913, H. K. Bishop writes: "We have ordered through Messrs. H. Hackfeld & Co., Ltd., two Shay Locomotives and 500 tons of 25 lb. rails. The rails reached Honolulu to-day, and the locomotives are on the way to San Francisco from Lima, Ohio" (Bishop, 1913, 11). C. H. Kluegel continues:

> "Six miles of track leading to the South portal from Pump 6, and three and a quarter miles of railway from Waikane landing to the North portal, was built; camps were built; work was laid out in the field; the power plants and machinery were installed, and the actual work of excavation and construction were well under way on October 1st, 1913."
> (Kluegel, 1916, 11)

It is important to note that these railroads were established for the primary purpose of transporting men, supplies, and heavy equipment in order to facilitate the construction of the tunnels. Although it is possible,

careful analysis of surviving photos does not indicate that these railroads were used for the removal of tailings from the tunnels. It is estimated that over 600 Japanese laborers were on the job sites at any given time; and, knowing that the tunnel operations ran 24 hours per day, it is likely that the railroads moved men and supplies in and out of the construction site.

Power Plant

Electrical power was crucial to the construction of the tunnels and ditches and establishing electric power was an enormous undertaking. Electricity provided the necessary power which ran the air-compressors for drilling tools, provided illumination and powered the ventilation systems for the workers. Power lines from the South portal were strung over the Koolau mountains to the North portal. Initially, power for the two headings was to be provided from a steam powered station located near the South portal; however, during the initial construction on the North portal, an abundant water source was discovered and plans were changed. At the North portal, water was used to power a small hydro-electric plant which provided enough energy for both portals. Kluegel writes:

> "This made an inexpensive and easily operated plant which was entirely satisfactory except at rare intervals when the water was low. The power was transmitted by pole line to the South portal in the opposite direction to that originally planned." (Kluegel, 1916, 18)

Detailed information regarding the development of the electric power plants at the South portal and North portal can be found in the Appendix 8.

Tools

A brief description of the power tools used is included here for clarification since many of the authors refer to these tools in their writings. Electric power provided a means by which to run air-compressors. These air-compressors provided power for a variety of machinery used in the construction of the tunnel. Chief among these tools was something called the Leyner drill which was required to drill holes in the rock in which dynamite was packed into and exploded.

Kluegel states that electrical and air power provided the means to operate the:

> ". . . sharpening machine; pumps; blacksmithing equipment; blowers for ventilation; a number of small machine tools for repair work, and facilities for making up the metal powder tubes used to hold large quantities of dynamite."
>
> (Kluegel, 1916, 19)

For further information about the tools used in the construction of the tunnel, refer to Appendix 2.

Dykes

Understanding what dykes are is absolutely crucial to the

understanding of the Waiāhole/Waikāne Tunnel. The word dykes is used throughout this paper and quoted from many sources. It should be noted that both spellings (dyke & dike) are used and both are correct.

Michael Mauricio writes:

> "The prehistoric volcano that makes up the Koolau had produced many fissures as it expanded and contracted. These were filled up with lavas which originated deep below the island, low in gas and minerals, and incredibly dense. These were not the soft lavas that flowed layer upon layer to build up the island, these were like great stone knives imbedded into the flesh of the mountain. They varied from four to forty feet thick and trapped the water of a million years of rain that had penetrated the porous lava in between them. These dike rocks, as they are known, were hard enough to blunt the toughest drill bits being used at that time. As if this weren't enough, the amount of water trapped between them was totally unexpected."
>
> (Mauricio, 1986, 6)

In 1916, Charles Kluegel wrote:

> "These dykes are hard, impervious strata of rock lying approximately at an angle of 45 degrees to the tunnel axis, and nearly vertical, and they occur at intervals of varying length. Between the dykes was the porous water-bearing rock, thoroughly saturated, and with the water pent up between the dykes often under considerable pressure, so that when a dyke was penetrated, the water would spout out from the drill holes and would gush forth form the openings blasted in the headings. As the work progressed, the water increase in quantity and the difficulty of the work was enormously greater on account of the water. . . The dykes varied in thickness from 14 feet down to about 4 feet, but all the dykes were composed of very hard, close-grained rock which was apparently water proof. All of the rock, however, was gritty and abrasive lava, and necessitated an unusual amount of drill sharpening, two of the latest type drill-sharpening machines being kept busy all the time."
>
> (Kluegel, 1916, 12)

Surveying and Triangulation

A brief mention of surveys is important here in that the critical nature of these surveys must be realized. Trying to bore a tunnel from opposite sides of the mountain can best be described as "challenging." The Koolau mountains are over 4,000 feet in height with one side of the range extending in valleys and ridges towards the Southwest while the other side is known for its shear cliffs or pali which plummet straight down from the peak of the mountains. Kluegel informs us that:

> "Great care was exercised in checking the surveys, the triangulations and the levels. This was given special care on the main tunnel, it being realized that while a small error in alignment would be unimportant, it would be necessary that all levels be correct. This levelling (*sic*) was done in the field by three separate parties, each of which went over the line twice, checking his own work, and the results of all three parties were checked against each other and found to compare within very small limits, thus eliminating any possibility of error. The instruments used for this work were thoroughly adjusted and tested for accuracy."
>
> (Kluegel, 1916, 10)

Once the surveys were completed, work on the tunnels commenced, first by hand in order to save time and push the work along, followed by more aggressive drilling once the air drills and machinery arrived.

Construction

Before launching into the actual construction of the tunnel a few facts are necessary in understanding the size and scope of the

undertaking before them. The construction of the main tunnel was started in February of 1913 and "was completed within a little over three years and the first water was delivered to Oahu Sugar Company on May 27, 1916. When built, it had the longest trans-mountain tunnel in the Territory" (Herschler, 1966, 1). Although other water projects may have been larger in size, the Waiāhole/Waikāne ditch and tunnel system was nonetheless an outstanding engineering accomplishment.

In deciding what elevation should be used for the entrance of the main tunnel, the Five Fingers Reservoir, on the leeward side, was chosen as the deciding factor. It was determined that water flow to this large reservoir would be necessary during the evenings when the water was not being used for irrigation. This back-up supply of water could then be tapped during periods of low flow. "The maximum elevation at which water is taken into the tunnel is 790 feet above sea level, and the grade or slope of the North side tunnels is 1.3 feet per thousand" (Kluegel, 1916, 6).

Herschler writes about the difference between the North Portal and the South Portal:

> "The construction of the main tunnel proved to be a real challenge. While excavation from the South Portal went along smoothly at a rate of about 630 feet per month, the story was quite different at the North Portal. Here, after excavating two hundred feet, the first dike was pierced which generated a flow of two million gallons per day. As more dikes were cut, the situation deteriorated . . . and the men were finding it difficult, if not impossible, to work waist-

> deep in the 66 degree water with torrential flows pouring down from the sides and roof of the tunnel."
>
> (Herschler, 1966, 3)

In October, 1913, only 9 months after construction began, H. K. Bishop resigned from his position as Chief Engineer, and it appears that there were many factors which lead to his decision. Chief among these factors were: the storms on the windward side which ravaged the construction site washing out roads and bridges built for the construction. There was also the unrest with the laborers, delays in receiving needed equipment, and a typhoid fever outbreak at the leeward camp which had to be contended with. In a letter to the Board of Directors of the Oahu Sugar Company, Bishop writes:

> "Hoping that the Inventory, Statements and final report herewith submitted will contain all the data you may wish for future reference, and trusting that you will have every success in the new manner of handling the work, I am, Sincerely, H. K. Bishop."
>
> (Bishop, 1913, final report)

Appendix 7 contains a copy of the last report to the Oahu Sugar Company titled "Final Report."

Following Bishop's resignation, Mr. Jorgen Jorgensen, Contract Engineer, assumed the job of Chief Engineer of the Waiahole/Waikane tunnel and ditch system.

The North Portal

The Waiahole/Waikane ditch and tunnel consist of many tunnels which are used to convey the water from the different valleys to the main tunnel which transverses the Koolau mountains. Construction of the main tunnel was started from both sides of the mountain range with the leeward side referred to as the South portal and the windward side called the North portal. The construction of these two portals began in February of 1913 under the direction of the chief engineer, Mr. H. K. Bishop. "Lacking the major equipment and power sources, the workers tore into the mountain by hand. . . At the North Portal, however, being closer to the stony heart of the mountain, the workers encountered such hard rock as to slow tunneling to a mere two-and-a-half feet per day" (Mauricio, 1986, 6).

Due to the size of the train cars used to remove the rubble and debris from the tunnels, it was found that a size of 7 feet by 7 feet would be sufficient for this purpose. It was also determined that this size would adequately transfer an amount of water up to 100 million gallons of water per day during periods of heavy usage.

The early stages of construction on the North Portal, was not without problems. H. K. Larrison states:

> "The north, or windward, portal of the main tunnel was located directly under the main springs which furnish the low flow of the Waiahole stream. It was anticipated that the tunnel would encounter the underground channels which fed these springs and the main tunnel was started

about three feet below grade and was gradually worked up to the real tunnel grade, to allow the water to drain out by gravity from the first thousand feet of the tunnel. . . The water encountered, instead of reaching a maximum of about ten or twelve million gallons per day as was expected, far exceeded this estimate, and as the bore progressed the amount of water increased until large siphons had to be installed to keep the water from driving out the workers. On June 26, 1914, when the north side bore had reached a point about 1700 feet from the portal entrance the water had increased to about 40 million gallons per day and the work on the north side had to be stopped on this account."

(Larrison, 1916, 83)

So much water was encountered that it became necessary to continually lower the floor of the tunnel in order to provide better drainage. This proved satisfactory until further penetration of the mountain was achieved and at 200 feet the first dyke was breached allowing millions of gallons of water to flow in on the workers. At this point in the digging, 2 million gallons were flowing into the main shaft daily creating unbearable working conditions due to the temperature of the water. Kluegel adds further information when he writes:

"At about 900 feet from the North portal, the flow of water having increased to 26 million gallons daily, the floor was again lowered to five feet below grade at the portal, and at this stage the men in the heading were working waist-deep in cold water, in a perfect torrent, the inflowing water coming principally from the face and from the roof and sides for a distance back from the heading, the flow of water apparently following the heading fairly closely."

(Kluegel, 1916, 12)

Harold Stearns, co-author of, *Geology and Ground-Water Resources of the Island of Oahu, Hawaii*, writes that the temperature of the water at

this point was a cool 66 degrees. It was at this point that work shifts were changed from 8 to 6 hours.

When it became clear that lowering the floor to drain out the water was no longer feasible, siphons were built and installed. The first siphon, made of redwood, was 16 inches in diameter and provided scant relief. At 1400 feet, the inflow of water was reaching 35 million gallons per day (mgd) and a second siphon pipe, 20 inches in diameter, was installed over the first pipe. Kluegel explains what happened next:

> "It was seen that the siphon method alone would not suffice for further drilling, so a relief or drainage tunnel was driven on the West side of and parallel to the main tunnel at a slightly higher level and on an ascending slope from the portal, its object being to intercept and drain off a portion of the troublesome inflowing water. This tunnel was required to provide access at all times to the water register to be installed at the boundary between Waiahole and Waiawa, distant 1705 feet from the North portal. . . The two tunnels were then worked together alternately, first one then the other, the floor of the main tunnel being kept above grade to avoid having the tunnel men work so deep in the water."
>
> (Kluegel, 1916, 14)

At 1700 feet into the North portal, a chamber was blasted out connecting the two tunnels and a pump capable of removing an additional 13 million gallons of water per day, was installed bringing further relief to the workers. By November of 1914 the inflow of water, which had collected behind the dykes, had decreased from 35 (mgd) to approximately 8 (mgd).

The South Portal

The story at the South portal was different from that of the North portal. Progress was rapid, sometimes averaging more that 21 feet per day. Work shifts in the South portal continued at 8 hours each with 3 men working the tunnel face or heading. At approximately 2 miles in, the first dyke was encountered and it was soon determined, from a drill hole, that the pressure of water behind the dyke was 67 pounds per square inch (psi) indicating that there was over 150 feet of water above the dyke. Work was stopped until a drainage system could be installed and the tracks of the cable cars raised over 12 inches to allow the water to drain out of the tunnel. Larrison writes:

> "In the south end of the tunnel little water was encountered until about March, 1915, when the heading was about ten thousand feet in from the portal; the maximum discharge of about fifteen million gallons was encountered about July 20th, and after that date the flow gradually decreased to about four million gallons daily about December 11."
>
> (Larrison, 1916, 83)

By the time the two tunnel headings met, it was determined that 80% of the length of the tunnel was bored from the South portal while only 20% from the North portal. These numbers would not have been so different had there been no water to contend with in the North portal which forced the development of a second tunnel to drain the excess water from the main tunnel.

Tunnel Headings Meet

Michael Mauricio writes:

> "By November the two faces were right on target, separated by a mere 300 ft. But what a task lay ahead! The final 100 yards were described in Thrum's Annual of 1916 as something resembling an underground hurricane and tidal wave combined, with streams of water bursting from the drill holes with such force."
>
> (Mauricio, 1986, 7)

On December 13, 1915, Jorgen Jorgensen reported that the two tunnel heading met and that the "alignment and grade were perfect, the length, however being 124 feet more than the original calculation" (Wilcox, 1996, 105). In addition, Mauricio writes: "Over 380,000 cubic yards of rock and an ocean of water had been removed to complete the Main Tunnel alone. Work still continued to connect the conveyance tunnels from the outlying valleys" (Mauricio, 1986, 7).

Tunnel Opened

The big day came on May 27, 1916, when the gates were opened and water from the Waiahole, Waikane and Kahana valleys flowed freely from the windward side of the Koolau mountains to the parched land in leeward Oahu. This momentous occasion was celebrated only three years and three months after the start of construction.

Mauricio informs us that: "After a short period of drilling developmental tunnels for dike water, work stopped and except for

routine maintenance, the tunnels remain virtually unchanged after seventy years of existence. Only a handful of men with the Waiahole Water Company tend to its needs" (Mauricio, 1986, 7).

Conclusion

In 1966, L. H. Herschler wrote:

> "The Waiahole system consists of a number of connecting tunnels on the windward side, which divert surface water from the many streams on the slopes of the Koolau Range, and four development tunnels from which ground water is obtained. The Main Tunnel, or trans-mountain tunnel, serves both as an interceptor of dike water and a conveyance tunnel to transport the water from the windward to the leeward side of the Koolaus. A series of tunnels, siphons and lined ditches on the leeward side then convey the water to reservoirs and to ditches of Oahu Sugar Company."
>
> (Herschler, 1966, 2)

The overall length of the tunnel and ditch system from Kahana valley to the plains of Ewa reaches some 22 miles.

The tunnel has remained unchanged since its completion in 1916. On my trip through the tunnel I got to see many wooden signs with numbers written on them, the meaning of which I was unable to discern. Something else of interest also runs through the tunnels: old communication lines that were strung through the tunnels by the military during World War II, connecting the windward and leeward sides of the island.

From mid-1916 to 1994, it is estimated that Oahu Sugar Company used an average flow of about 35 to 40 (mgd) to irrigate their fields and that most of this water came from the dyke compartments within the mountain. Some 4,000 acres of sugar cane received this water, everyday, creating more wealth to those who controlled this precious resource. Taking these numbers into account, it is clear that over one-and-a-half billion gallons of water have been diverted from the windward side of the island to the leeward side.

The above data seems to conflict with Carol Wilcox's assessment concerning the amount of water taken from the windward side of the Koolau mountain range. Wilcox states that the average flow was only 28 million gallons per day, and that water diversion projects in the Waiāhole, Waikāne, and Kahana valleys only contributed 2 million gallons per day and that most of the water used was developed from tunnels penetrating the mountain. (Wilcox, 1996, 106).

My conversations (March 2004) with those people who operate the system confirm that Carol Wilcox's figures are correct.

Epilogue:

In 1986, Michael Mauricio wondered what would happen to the water when the sugar fields closed down.

> "What will happen to the tunnels after Oahu Sugar closes its doors is anyone's guess. Many are looking forward to utilizing the water for other industrial uses, but more than

> likely, the tunnels will be sealed and the waters will return to the path they followed to the ocean over 80 years before."
> (Mauricio, 1986, 7)

Chapter 5, Historical Perspective, will take a reflexive look at the impact which sugar plantations had made on the Hawaiian people. Two questions will be addressed in Chapter 5. Who gained from projects such as the Waiāhole/Waikāne ditch and tunnel system? And, more importantly, who lost?

In Chapter 6, *Contemporary Issues*, I will take a closer look at the issues surrounding the closing of Oahu Sugar Company in 1994, and the subsequent argument that there is a continued need for the Waiāhole Water Ditch System and the water it provides.

Chapter V

Historical Significance

The purpose of this chapter is to take a "look-back" at what happened to the Hawaiian people once contact with Westerners was made. Specifically, I will attempt to bring into focus how industries, such as the sugar industry which belonged to the haole elite, brought about cataclysmic changes to both the people and the landscape of the Hawaiian Islands. In doing the research for this chapter, I found no shortage of authors wishing to make their point in regards to changes made on the Hawaiian landscape.

In this reflective "look-back," it is my desire to give a strong voice to a Hawaiian writer whose work epitomizes the struggles which her people have made in an attempt to understand how it is that Hawaiians have become disenfranchised from their own ʻĀina (land). In that effort, I will begin and end this chapter with a quote from Lilikalā Kameʻeleihiwa, author of *Native Land and Foreign Desires*. Looking back on history, Kameʻeleihiwa focuses on two important events which contributed to the downfall of the Hawaiian people:

> "Today, many Hawaiians are searching our history to discover how it was that we slipped to the bottom of society and became strangers in our own country. Recently, much attention has been focused on the 1893 overthrow of Queen Lili'uokalani and the demise of the Hawaiian monarchy. But the real loss of Hawaiian sovereignty began with the 1848 Māhele, when the Mōʻī (monarchy) and Aliʻi Nui (ruling

> chiefs) lost ultimate control of the 'Āina (the land). It is not surprising that as foreigners gained economic control of the 'Āina they began to desire political control as well. In the sweep of history, it is but a short step from the 1848 adoption of private ownership of 'Āina to the 1893 overthrow of the Hawaiian government."
>
> (Kame'eleihiwa, 1992, 15-16)

Clearly, the two events which Kame'eleihiwa wrote about are significant chapters in Hawaiian history and have been addressed by many authors. I have already addressed the Great Māhele and the Overthrow in chapter two, thus needing no further explanation.

The question which needs an answer is, "So what? So what then; so what now? What did these plantations mean for the Hawaiian people?"

Clearly, the changes brought upon the people of Hawaii began with the arrival of Captain Cook, and there is no question that these changes continue to this day. This chapter will explore these changes and look at the effect that they had on the local population.

"So what then?" I believe I have answered this question in chapters 2 and 3. As a brief recap, the Hawaiians had a vibrant, healthy and sophisticated society in which most Hawaiians (some historians would argue that all Hawaiians) enjoyed a lifestyle free from hunger and diseases. David Stannard, author of *Before the Horror*, argues that the population of Hawaii may have approached figures close to a million people although other authors disagree with that figure. It should be

noted that the Hawaiian people were a physically active and industrious people providing surplus foods in which everyone partook, thus creating a society in which everyone benefited. This is not to say there were not problems associated within the Hawaiian culture—it is not the premises of this paper to go into those aspects of Hawaiian society.

The answer to the question, "So what now?" in its simplistic terms is simply "plenty." Not only did Westerners manage to change the way in which Hawaiians had lived for centuries, but within a short period of time the westerners had managed to erase anything resembling a pure Hawaiian with the exception of a very few isolated people. Made possible by the Great Māhele, and beginning in mid-1800s, sugar plantations began to make changes to the Hawaiian environment and, later, to the people of Hawai'i.

In regards to the island of O'ahu, changes to the Hawaiian environment accelerated due to the discovery of abundant ground water in the leeward plains. With this discovery of ground water, thousands of acres of land became available for the production of sugar cane. More acreage of sugar cane meant more profits for the haole elite which, in turn, led to the development of more lands for more production. Although underground water sources were available for the parched lands of leeward O'ahu, it became necessary to utilize the water from the windward side of the island to quench the thirst of sugar cane.

The question remains, "So what?" As these plantations grew, so did the desire of the haole elite to extract more and more profits from the land. The two things which stood in the way of these profits were the availability of abundant and inexpensive sources of water and the availability of thousands of laborers willing to work for subsistence wages. Tens of thousands of laborers were needed in an effort to support the growth of the sugar plantations. Carol Wilcox states the following:

> "Almost the entire sugar industry was peopled by immigrants: entrepreneurs, investors, engineers, laborers, skilled workers, and craftsmen came from the Pacific Islands, China, Japan, Korea, the Philippines, Europe, and the United States. This was true of the sugar industry as a whole and of water development too."
>
> (Wilcox, 1996, 15)

What about water? As we have seen from the above chapters, water was diverted for the purpose of providing this resource to the fields as cheaply as possible. So what? How did this affect the Hawaiian people? The answer is two-fold. First, the Hawaiian people who relied on these resources to irrigate their own fields of kalo were denied access to the resources which they considered as their own. Deprived of the necessary water by which to feed their crops, the Hawaiians began to find themselves dispossessed of the very lands which had sustained them for nearly two thousand years.

Secondly, the importation of tens of thousands of immigrants, mostly men, began to make their mark on the Hawaiian scene.

Fuchs noted that "The quest for cheap labor never ceased . . . until 1930, approximately 400,000 men, women, and children were transported to the plantations of Hawaii" (Fuchs, 961, 24).

Importation of these laborers eventually led to a "melt-down" of Hawaiian purity as these men of differing nationalities desired the comfort of a woman and began to intermarry with local women, producing off-spring of mixed blood. Nordyke confirm this change:

> "In the last two hundred years since the arrival of persons from other parts of the world, Hawaiian blood has blended with many nationalities. The miscegenation of Hawaiians during ten or more generations has confused the anthropological identification of this race and altered the biological factors of their genetic continuity. Presently most Hawaiians are Part Hawaiians who can trace mixed background with Whites, Chinese, Japanese, Filipinos, Portuguese, and other ethnic peoples who came as foreigners to the land of the Hawaiians."
>
> (Nordyke, 1989, 30)

Fuchs confirms Nordyke's interpretation of these times with these words:

> "In one fundamental respect Hawaii was unique—neither like anything in America nor like any other plantation colony. Miscegenation and intermarriage were not only widespread, but accepted, and, in some cases, approved. Perhaps as many as thirty of the early white residents married Hawaiian women of chiefly rank. The existence of the mission depended, in its earliest days, on the good will of native chiefs and royalty, and haoles could not oppose marriages favored by Hawaiian leaders."
>
> (Fuchs, 1961, 38)

Not only were the Hawaiians losing their own self-identity through intermarriage, they were finding themselves forced into a new system of economics based on the plantation. The transformation (or degradation, depending on one's outlook) of the Hawaiian landscape is explored by Kent when he writes:

> "By 1876, the haole merchants and planters and missionaries had reformed the Island economic structure essentially after their own image. Their plantations, stores, steamships, churches and weekly brass band were drowning out the traditions of the past. Hawaii was bound tightly in the existing commercial network of the world; and Hawaii's future was the future of its plantation economy."
>
> (Kent, 1983, 47)

The question was asked, "So what then? So what now?" The answer is simple. The Hawaiian people were better off before the arrival of Westerners. Today, the Hawaiians are still dispossessed from their lands and the gap seems to grow wider with every passing day. Lately, we see in the newspapers the effect that "outsiders" are having on our local economy. "Snowbirders" (those who come to Hawaii during the winter) are buying up property at prodigious rates which further hurts those who are already disenfranchised from their lands.

I have used the words of several authors to show how the plantation economy affected the Hawaiian people. There is much that has been written on this subject with more yet to be written. Suffice it to say that sugar, with all of its ramifications, changed Hawai'i in ways few could have anticipated 150 years ago. Clearly, the haole elite in their

quest for more and more profits found ways to exploit the land and people of Hawai'i, thus disenfranchising these Hawaiians from their culture and heritage.

I will conclude this chapter with a sad piece written by Lilikalā Kame'eleihiwa:

> "As modern Hawaiians we are without 'Āina and without voice. It has been two generations since many of us have spoken our ancestral language, and as language is the soul of culture, many of our people have become ashamed of our Hawaiian identity. And many of us are desperately poor: we are homeless, we live on beaches, in cars, and even in caves. Many of us who have houses to live in, even Hawaiian academics like myself, are only one paycheck away from the streets. Life is difficult, and in such circumstances we may well ask: of what use to us is history?"
>
> (Kame'eleihiwa, 1992, 321)

Chapter VI

Contemporary Issues

Over the last 15 years many authors have written about the contemporary issues regarding the use of the Waiāhole/Waikāne water once O'ahu Sugar Plantation closed down. The amount of material available for research on this subject would fill volumes; however, this paper's focus is not meant as an instrument for this debate. This conclusion to this paper will touch upon a few issues which were important to the discussion of stream restoration, primarily the restoration of water to the Waiāhole and Waikāne streams on the windward side of O'ahu.

Environment Hawaii, a monthly newsletter, has over 40 listings of articles which have been written about the Waiāhole/Waikāne water system. These articles, dating back to 1990, can be found in Appendix 10. Included in this listing are a few articles about other on-going stream restoration projects in Hawaii which may be of interest to those seeking further information about contemporary water issues in Hawai'i.

By 1995 most of the sugar plantations had closed their doors bringing an end to the hundred year reign of King Sugar. With King Sugar's demise, it became apparent that millions of gallons of water would become available for other uses. What was to become of this

water was left up to the Commission on Water Resource Management, which was guided by the 1987 Water Code. (Wilcox, 1996, 9).

A brief explanation of how this Water Code of 1987 came into existence is addressed by Vivian Lee, author of *Ho'i Ka Wai*, writes:

> "At the 1978 State Constitutional Convention, water rights became an issue and a state water code was mandated. Nine contentious years later (1987), the legal basis for stream restoration was finally established when the Hawai'i State Legislature adopted the State Water Code. It was to be administered by the Commission on Water Resources Management, commonly known as the Water Commission."
>
> (Lee, 1997, 123)

(Note: Throughout the rest of this conclusion, I will refer to the Commission on Water Resources Management as simply the Water Commission.)

The Water Commission's task was not an easy one. One hundred years of abusive water policies needed to be un-done almost overnight. Environmental concerns became the watchword as the Water Commission found itself embroiled in issues:

> ". . . such as traditional and customary Hawaiian rights, protection and procreation of fish and wildlife, ecological balance, scenic beauty, public recreation, beneficial instream uses, and public interest. Hawaii's government and people, therefore, are facing big questions. How they are resolved will have broad economic and social implications."
>
> (Wilcox, 1996, 9)

When it became clear that O'ahu Sugar Company would be shutting down its operations, community groups banded together in an

effort to have the water, which had been diverted for 80 years, returned to their original stream beds. Vivian Lee states the following:

> "In December 1993, community, native Hawaiian, and environmental organizations petitioned the Water Commission to restore water to Waiāhole and Waikāne Streams and thereby replenish populations of native stream animals, increase potential for taro cultivation, and enhance the productivity of the Kāne'ohe Bay estuary, into which the affected streams flow."
>
> (Lee, 1997, 123)

In response to these community groups, the recently formed Water Commission set a hearing date for June 22, 1994. Jim Anthony, one of the speakers, testified:

> "The time has come to right the wrongs of the past. The time has come to return all of the water that goes to the Waiāhole Ditch back into all of the streams between Kahana and Waiāhole. That time is now. By restoring all these streams, with 25 to 30 million gallons of water a day, we will be able to restore the quality of near shore waters, and water will be available in the windward area for small-scale agriculture, including especially taro."
>
> (Water Commission, 1994, 33)

Further testimony was provided by Charlie Reppun, a community activist, who read from a report titled *Coconut Island Report* which stated:

> "Brackish water areas are crucial for many important marine fisheries. . . They are a critical link in the marine food chain. Fishery species which utilize stream, estuarine habitats in Kāne'ohe bay include 'ōpae, nehu, mullet, āholehole, moi, awa, lizard fish and pāpio. Kāne'ohe bay once had 70 million gallons a day of fresh water flowing into it by way of its streams. Over 50 percent of that water no longer enters the bay."
>
> (Water Commission, 1994, 19)

The point made by Mr. Reppun was that these marine species have decreased dramatically due to the diversion of fresh water and that restoring the water flow to the Waiāhole stream would increase fish populations.

Opposing views concerning the stream restoration was voiced by leeward landowners who wished to continue using all of the diverted water. A compromise was reached in which the "leeward parties agreed to a six-month arrangement that returned about half the diverted water to the streams" (Lee, 1997, 123). The amount of water returned to the streams totaled some 21 million gallons of water per day (mgd).

At the end of the 6 month trial period, AMFAC, owners of the water system, wanted to again divert the water back into the tunnels for the benefit of the leeward landowners. This decision was not acceptable to the windward residents who staged a peaceful demonstration in an attempt to block the re-diverting of water back into the tunnels. This peaceful blockade achieved its purpose and today the water continues to flow into the streams of Waiāhole, Waikāne, and Waianu.

The State of Hawai'i Steps into the Fracas

With the closing of the O'ahu Sugar Plantation in 1994, the State of Hawaii in 1998 purchased the rights to the Waiāhole Ditch and Tunnel system and placed its care under the Waiāhole Water System, a department within the Agribusiness Development Corporation, State of

Hawai'i. Although the argument for and against the purchase of the Waiāhole Water System could fill a dissertation, a few key points should be mentioned.

Those in opposition to the purchase of the Waiāhole Water System were Environmental and Hawaiian groups. The Sierra Club and the Earthjustice Legal Defense Fund also opposed the purchase.

Those in favor of the purchase were leeward farm owners whose dependency on adequate supplies of cheap water cannot be overstated. Another key proponent was the Board of Water Supply which voiced its concern over the continued use of the Pearl Harbor aquifer, citing over-use as detrimental to the health of the aquifer. The bill passed the legislature and the State of Hawaii finalized the purchase of the Waiāhole Water System.

> "Governor Cayetano signed the bill to acquire the ditch on June 5, 1998, making it Act 109 of the 1998 legislative session. The act allows the state to spend $9.7 million . . . to acquire and operate the ditch system through the state Agribusiness Development Corporation (ADC)."
>
> (Environment Hawai'i, 1998)

The Future of O'ahu Water

In response to small agribusiness owners who were concerned over the future of water which was needed for the production of agricultural products, the Department of Land and Natural Resources chief Timothy Johns had this to say:

> "The forecast over the next decade is very favorable. However, over the longer term, 20 or 30 year, certain areas of Oahu may run out of natural supplies of ground water. Small businesses can probably expect continued availability of relatively inexpensive drinking water and increasing availability of treated wastewater for reuse. Costs may be added to comply with regulatory, monitoring and planning expenses. Secondly, they can expect continued availability of agricultural water, with costs that will vary within each system. Finally, the concept of integrated resource planning will ensure conservation, consideration of alternative sources of potable and non-potable water and the opportunity for competing values to be addressed and integrated with future planning."
>
> (Whitney, 1999, 58)

In regards to water resources necessary for resort and golf course use, the State and City and County are moving in the direction to use "gray water" (treated sewage water) for these purposes. In order to deliver this "gray water" to potential users, substantial infrastructure projects will need to be designed and built into every future project whether it be residential or resort.

Restored Water

On the Windward side of the island I saw firsthand the amount of effort the State of Hawaii has undergone in restoring water to the Waiāhole stream. As of this writing (April 2004) vast amounts of water are no longer being diverted into the ditch and tunnel system. Some 21 million gallons of water per day are now flowing freely into their original stream beds which guide the waters through the lush forest of Waiāhole and Waikāne and into the bay of Kāne'ohe.

In closing, I wish to express my gratitude to those who made it possible for me to undertake a tour that few individuals will ever experience. It was humbling to see firsthand the engineering feat of Jorgen Jorgensen, the man responsible for my family's coming to Hawaii. I am forever grateful for this opportunity and indebted to those who made it possible for me to experience a trip of a lifetime.

I conclude my paper with these words from Carol Wilcox:

> "Just as the beginning of the twentieth century was a time of great change, so change marks the end of that century. A look at the past is essential in fact, as we step into the future. One can admire the vision and initiative of the early sugar planters while at the same time mourning the loss of water resources and authentic Hawaiian lifestyle. The era dominated by sugar gives way to new times, new challenges, and new opportunities. Among them is a chance to manage water resources wisely for future generations."
>
> (Wilcox, 1996, 11)

Works Cited

Bishop, H. K. (1913) *Progress Report for the Month of February, 1913, on the Koolau Tunnels*, March 24th, 1913, Honolulu: T. H.

Bishop, H. K. (1913) *Final Progress Report of H. K. Bishop on the Koolau Tunnel*, October 1st, 1913, Honolulu: T. H.

Bull, E. K.(1913) *Water Development*, Special Report of the Oahu Sugar Co. Ltd., Year ending December 31st, 1912, Honolulu: T. H.

Nā Maka o ka ʻĀina (2001) *Commission on Water Resource Management (Water Commission) public meeting on Waiāhole Ditch, June 22, 1994, Waiāhole, O'ahu.*

Daws, G. (1968) *Shoal of Time: A History of the Hawaiian Islands*, Honolulu: University of Hawai'i Press.

Dening, G. (1980) *Islands and Beaches: Discourse on a silent land: Marquesas 1774-1880*, Honolulu: University of Hawaii Press.

Dorrance, W. H., Morgan, F. S. (2000) *Sugar Islands: The 165-Year Story of Sugar in Hawai'i*, Honolulu: Mutual Publishing.

Automatic Approval, Waiahole Ditch Purchase Pass Legislature's Muster, Environment Hawai'i, Vol. 9, No. 1, July 1998. (web based information, no page numbers)

In 1912, Waiahole Farmer Sought To Insure 'Plentiful Supply of Water', Environment Hawai'i, Vol. 5, No. 4, Oct. 1994. (web based information, no page numbers)

Fuchs, L. H. (1961) *Hawaii Pono "Hawaii the Excellent" An Ethnic and Political History*, Honolulu: Bess Press.

Griffin, B. P., Pyle, D. (1974) *The Archaeology of Koolau-Poko, O'ahu: from the ahupua'a of Waiahole to the ahupua'a of Waikane*, Honolulu: Environmental Communications, Incorporated, Archaeological Research Center Hawaii.

Handy, E. S., et al (1965) *Ancient Hawaiian Civilization, A series of lectures delivered at The Kamehameha Schools*, Vermont: Charles E. Tuttle Co.

Herschler, L. H. (1966) *Fifty Years of Water Service*, Honolulu: The Waiahole Water Company.

Ishikawa, S. (1999) *Historic papers lost in fire*, Honolulu Advertiser, April 2, 1999.

Kame'eleihiwa, L. (1992) *Native Land and Foreign Desires*, Honolulu: Bishop Museum Press.

Kent, N. J. (1983) *Hawaii: Islands Under the Influence*, Honolulu: University of Hawai'i Press.

Kluegel, C. H. (1916) *Engineering Features of the Waiahole Water Co. Island of Oahu, Territory of Hawaii*, Honolulu: Hawaiian Engineering Association.

Larrison, G. K. (1916) *The Waiahole Tunnel Project*, Hawaiian Forester and Agriculturist, vol. XIII, 81-83.

Lee, V. (1997) *Ho'i ka Wai: The Waiāhole Stream Restoration*, Honolulu: University of Hawai'i Press.

Mauricio, M. (1986) *Sugar Legacy*, Honolulu: Plantation Village News, vol. X, No. 3, September, 4-7.

Mid-Pacific Magazine, (1916) *Biography of Jorgen Jorgensen*, Honolulu: January to June, vol. 11, 170.

Nordyke, E. C. (1989) *The Peopling of Hawai'i*, Honolulu: University of Hawaii Press.

Rogers, R. F. (1995) *Destiny's Landfall: A History of Guam*, Honolulu: University of Hawai'i Press.

The Waiahole Tunnel Project, Hawaiian Annual, Honolulu, 1916, 174-181.

Water for Life The History and Future of Water on O'ahu, Honolulu: Honolulu Board of Water Supply, Info Grafik, Inc., 2003.

Whitney, S. (1999) *Water Means Business*, Honolulu: Island Business The Hawaii Report, vol. 4, No. 4, April, 17-18, 57-58, 60.

Wilcox, C. (1996) *Sugar Water: Hawaii's Plantation Ditches*, Honolulu: University of Hawai'i Press.

Siddall, J. W. (1925) Builders of Hawaii: Story of Hawaii and Its Builders, Honolulu: Honolulu Star-Bulletin, vol. 3.

Standard, D. E. (1989) *Before the Horror The Population of Hawai'i on the Eve of Western Contact*, Honolulu: University of Hawaii Press.

Stearns, H. T., Vaksvik, K. N. (1935) *Geology and Ground-Water Resources of the Island of Oahu, Hawaii*, Honolulu: U. S. Geological Survey, May, 399-409.

Tummons, P. (2002) *Final Decision in Waiahole Case Changes Little for Windward Streams, Leeward Farmers*, Environment Hawai'i, Vol. 12 number 8, Feb. 2002, (web based information, no page numbers)

Young, L. P. (1975) *The Chinese on Windward Oahu: Waiahole, Waikane and Hakipuu*, Honolulu: Hawaii Chinese Center, November 3, 1-6.

Appendix 1

Tunnel Specifications

The article *Geology and Ground-Water Resources of the Island of Oahu, Hawaii* by Stearns and Vaksvik describes in detail the construction of other related tunnels which were part of the entire ditch system. A brief list is provided for information purposes.

Drainage tunnel R. 1,663 feet.

"Tunnel R was driven just above the north portal of the main bore for drainage, and except for one flow of pahoehoe it is all in aa basalt. It was completed in June 1915 with a length of 1,663 feet and went dry 10 months later. Its peak flow of 9,000,000 gallons daily was reached in May 1915" (Stearns, 1935, 404).

Data from Stearns' article.

Tunnel A	735 feet	1914
Tunnel B	1,260 feet	1915
Uwau tunnel	1,104 feet	1932
Waikāne tunnel 1	2,128 feet	1925
Waikāne tunnel 2	2,342 feet	1927
Kahana tuneel 1	1,975 feet	1929

Other tunnels constructed by the Oahu Sugar Company are Waikakalaua Tunnels one and two and the Kaukonahua tunnels.

Principal Features of Project

"Main tunnel—Length, 14,567 feet; elevation above sea level, north portal about 750 feet and south portal about 725 feet; cross section of tunnel is 8 feet deep and 7 feet wide with an average depth of water at about 5 feet. Maximum capacity 125 million gallons daily" (Larrison, 1916, 83).

"The work was started in January, 1913, and the water will be turned into the tunnel about May 1, 1916. The total cost of the project is said to be about $2,300,000" (Larrison, 1916, 83).

Closed Conduit System

"This system of tunnels is essentially a closed-conduit system—that is, the flow is entirely through closed tunnels, not subject to interruption by freshets or washouts or from rubbish or wash from the mountain streams, the intakes being so built as to admit only water as free from rubbish as practicable. Only at three points in the tunnel system—and these are on the South side, one of which is a gauging station—does the water flow in open channels for an aggregate length of 160 feet" (Kluegel, 1916, 24).

"Pipes were not a part of the contract to Mr. Jorgen Jorgensen. Steel pipes were let out to contract to the Lord-Young Engineering Co. The last of these pipes has just been completed. The contract for the redwood pipes was let to Lewers & Cooke, Ltd." (Kluegel, 1916, 24).

"It is intended to use the reservoirs so far as possible to take care of the water flowing at night, so as to utilize the conduit to its fullest capacity" (Kluegel, 1916, 24).

"The Waiahole Water Co. has taken over from the Oahu Sugar Co. the Ahrens Ditch in Waiawa, the Kipapa Ditch, the Waikakalaua ditch in Waipio, and the Hoaeae Ditch. Two redwood pipes having total length of 1223 feet have been laid across two gulches on the line of Hoaeae Ditch, cutting out 2 ¼miles of ditch" (Kluegel, 1916, 24).

"The water delivered by the Waiahole System is chiefly used on newly-planted cane on land above the lift of the pumps. During construction the water developed in the main tunnel near the South portal was at times utilized for irrigation. On May 27, 1916, with Mr. H.

Olstad as Superintendent, continuous operation of the project was begun" (Kluegel, 1916, 24).

From the General Plan

There are 27 of these tunnels on the North side, varying in length from 280 feet to 2332 feet, the aggregate length of the North side tunnels being 24,621 feet, or 4.66 miles, being in reality one continuous tunnel. The number of adits at which water is taken in is 30, the intakes being located at the most advantageous points at the streams in the gulches" (Kluegel, 1916, 6).

"The maximum elevation at which water is taken into the tunnel is 790 feet above sea level, and the grade or slope of the North side tunnels is 1.3 feet per thousand" (Kluegel, 1916, 6).

"The water is also delivered into numerous reservoirs, especially at night, when irrigating the cane fields is inconvenient. One of the larger reservoirs, on the line of the Waikakalaua storm water ditch, has long been in use. It is called Five Finger Reservoir. Its elevation was a determining factor in establishing the grade elevation of the Waiahole conduit" (Kluegel, 1916, 6).

In reference to pipes and siphons Kluegel writes: "The intakes and outlets of these pipes consist of a heavy construction of concrete, reinforced, and the intakes are provided with iron grating bars to prevent the access of floating material of any kind, and as a safety precaution in case of a person or animal accidentally falling into the ditch near the pipe" (Kluegel, 1916, 7).

"Provision is made by means of valves at the lowest point of the Kipapa Gulch pipe to take out water for irrigating the lands in Kipapa Gulch, and other lands lying below that level, and also for power purposes, should this latter become desirable at some future time; the water from the tail-race of the power plant being then available for

irrigation after delivering up its power, the available hydraulic head at this point being 280 feet" (Kluegel, 1916, 9).

Measurement of Water

"The main bore through the mountain was intended at the beginning to be merely a conduit to convey the water form one side to the other, but in the process of building the tunnel, water was developed so that this became a source of supply, and for this reason it is necessary to measure the flow at certain boundaries as a basis of payment for the water to the owners of the land. Two stations for the measurement of water are operated, one at the boundary of Waiahole and Waiawa, and one between lateral tunnels H and I on the South side, measurements a these points being all that are required for payment of the water. These stations are in channels of uniform sections which are rated, and the stage of water is recorded by an automatic water stage register, thus giving a permanent record of the daily flow as a basis for payment" (Kluegel, 1916, 23).

"The maximum quantity of water developed was on October 16, 1914, and was approximately 35 million gallons daily from the North portal. The flow of water has varied considerably from time to time, and has been decreasing, apparently indicating that the water stored in the mountain between the dykes is gradually being drained off. It is thought that the permanent or continual flow from the tunnel bore will be governed by the rainfall over this drainage area. The present flow of water percolating into the main tunnel is 14 million gallons daily. This appears to be the dry weather flow" (Kluegel, 1916, 23).

"The North System (windward) consists of 27 connected tunnels and 37 stream intakes and four development tunnels. It extends from Kahana Valley at elevation 790 feet to the Main Tunnel (Waiahole Valley) at elevation 752 feet, a distance of 4.66 miles with an average slope of

1.5 feet per thousand feet. The longest tunnel in this system is 2,332 feet and the shortest 280 feet. The Main Tunnel is 2.76 miles long extending from the windward side at elevation 752 feet to the leeward side at elevation 724 feet. Thirteen tunnels ranging in length from 346 feet to 3,329 feet continue westerly from the South Portal of the Main Tunnel to take the water to the beginning of the open ditch system at elevation 699 feet in Waiawa. This ditch (mostly lined), carries the water farther westward to the end of the plantation in Honouliuli at an elevation of approximately 600 feet. In addition, there are 1.38 miles of siphons required for gulch crossings. The longest is 2,034 feet. Two of the four steel siphons are 78" in diameter and the other two, 72". The three redwood-stave siphone are 60" in diameter. The capacity of the main aqueduct system is approximately 125 to 150 million gallons per day" (Herschler, 1966, 2)

Appendix 2

Tools

"The local plant at each portal contained a duplex 2-stage Ingersoll-Rand air compressor, supplying 800 cubic feet of free air per minute, at a pressure of 100 pounds per square inch, belted to electric motors; receiver; Leyner drills; sharpening machine; pumps; blacksmithing equipment; blowers for ventilation; a number of small machine tools for repair work, and facilities for making up the metal powder tubes. The air drills used were the water-Leyner drills up to 10 feet long. These drills use a jet of water under pressure which forces out the cuttings from the point of the drill. They are capable of rapid drilling, there being very little interruption form the clogging up of cuttings" (Kluegel, 1916, 19).

"Air was supplied to the drills by a 4-inch pipe line running to a manifold which was always near the heading. Each round required from 12 to 20 holes, eight to ten feet depth, the holes being drilled at slightly converging angles in order to break the rock effectively. Each round required form 50 to 100 pounds of 40% or 60% dynamite, Giant brand being used" (Kluegel, 1916, 19).

"The ventilation of the tunnel headings was secured by forcing air by means of blowers through 16-inch metal pipes which were carried along the side of the tunnel, the air being forced in continuously. When a shot was fired, the direction of the blower was reversed for a while, and the smoke and foul air was drawn out of the tunnel through the pipe until it was clear and fit for the men to work. This arrangement of ventilation proved effective and saved a great deal of time" (Kluegel, 1916, 20).

Appendix 3

Mid-Pacific Magazine
January - June 1916: page 170

WHO'S WHO IN HONOLULU.

JORGEN JORGENSEN, Civil and Hydraulic Engineer, was born in Denmark, 1866, and educated at the Latin School of Nyborg and the University of Copenhagen. Entered the Danish Army School for Officers, and graduated from same in 1888; commissioned Second Lieutenant of Engineers, served as such one year. Came to the United States in 1889, engaging in surveying and engineering work on the Pacific Coast for several years, and then served in the United States Army Volunteer Engineering, mostly hydraulic, in the Territory of Hawaii. Was resident engineer on the two great irrigation aqueducts at Koolau, Maui, and Kohala, Hawaii, and was later Chief Engineer of the Upper and Lower Hamakua Ditches, Hawaii. In October, 1914, he undertook the building of the great Waiahole Water Project on a contract base.

Mr. Jorgensen is a member of the Pacific, Commercial and Country Clubs as well as a prominent Shriner and Elk. He is at present making his home in Honolulu where he has his office in the Hawaiian Trust Building, and residence on Kalakaua Ave.

Builders of Hawaii: Story of Hawaii and Its Builders
By J.W. Siddall: v. 3, 1925

Jorgen Jorgensen
Civil and Hydraulic Engineer

A resident of Hawaii continuously since 1898, except for a period of service in the army of his adopted country during the World War, Jorgen Jorgensen has designed, supervised and carried to successful completion a number of the most important engineering projects in the Territory having to do with the development and diversion of water for the irrigation of sugar plantations, and involving the expenditure of millions of dollars.

The most notable of his professional achievements was the Waiahole water tunnel, constructed at a cost of $2,000,000 to bring water from windward Oahu to the great plantations of the leeward side of the island. He was consulting engineer on this project in 1911-12, and was the contracting engineer, 1913-16. Unusual engineering problems were encountered and solved in the handling of this work, which included the boring of eleven miles of tunnel, and its completion marked the fulfillment of the greatest work of the kind yet undertaken in Hawaii.

Mr. Jorgensen, as resident engineer, also directed work on the Koolau Ditch, Maui, in 1902-04, a $600,000 project, and the Kohala Ditch, Hawaii, 1904-05, which cost about $700,000. He was chief engineer of the Upper and Lower Hamakua ditches and reservoirs, 1905-11, a $1,200,000 project. He was a member of the Honolulu Water Commission in 1916 and has made numerous reports on different water projects and other engineering works in Hawaii. He made a report to the old Lanai Company in 1910 and located a tunnel in Maunalei Gultch which resulted in opening up the only steady water supply of fresh water on Lanai. In 1924 this was supplemented by another tunnel, doubling the water supply, for the Hawaiian Pineapple Co. He also located and surveyed the main pipe systems on the Parker and Maguire ranches, Hawaii, and increased the water supply of the Molokai Ranch of the American Sugar Co.

Since 1922 Mr. Jorgensen has been engineer for the Hawaiian Homes Commission, engaged in developing water resources on Molokai, and he has

also made water surveys on Lanai in connection with the Hawaiian Pineapple Co.'s great development program on that island.

Born in Denmark, Sept 12, 1866, the son of Jorgen and Mette (Jorgensen) Jorgensen, Mr. Jorgensen was educated in the Latin School of Nyborg, University of Copenhagen and the Danish Army School for Officers, graduating in 1888 as a lieutenant and serving one year in the Royal Danish Engineers.

Coming to America in 1889, Mr. Jorgensen spent the next nine years in land and railroad surveying in Washington and Oregon, and in the Spanish-American War, 1898, served for ten months as a sergeant of Volunteer Engineers, coming to Hawaii during this service. He was assistant engineer for the McBryde Sugar Co., 1899-1901, and engineer for the Koloa Sugar Co., 1901-02, in the latter year beginning his distinguished career as a hydraulic engineer.

Entering the American army for World war service as a major of engineers on Jan. 5, 1918, at Camp Lee, Va., Mr. Jorgensen was variously assigned to the First, Second and Third Engineers, replacement troops, and commanded the 154th Engineers at Camp Shelby, Miss., where he was honorably discharged on Dec. 15, 1918. He was promoted to lieutenant-colonel, Officers' Reserve Corps, Aug. 14, 1923.

When the American Legion was organized in Hawaii, Mr. Jorgensen was elected vice commander of the Department, Sept. 4, 1919. He has been a delegate to all department conventions of the Legion and was a delegate to the fifth national convention, San Francisco, in October, 1923. He was appointed to the Committee on Americanism, 1924, by the national headquarters of the Legion. Mr. Jorgensen is a member of the American Association of Sugar Technologists, Chiefs of Hawaii, Commercial Club, Pacific Club, Chamber of Commerce, charter member of the Hawaii Polo & Racing Association, and a Scottish Rite Mason, Shriner and Elk. He is member of Honolulu Post, American Legion, and Theodore Roosevelt Post, United Spanish War Veterans. Mr. Jorgensen married Hyla Brand Coonley in San Francisco, Dec. 12, 1916.

Appendix 4

Additional material not used in the paper

"Developing surface water and transporting it long distances via tunnels and ditches was not new to Hawaii. In ancient days the Hawaiians had constructed elaborate "auwai' systems for growing taro, and the first irrigation ditch for sugar cane" (Herschler, 1966, 1).

"The industrial condition which brought this project to completion was, briefly, the necessity for bringing the perennial mountain streams from the windward side of Oahu, where there is little need of them, through the rough Koolau mountain range which forms the backbone of the island, to irrigate the broad, rich, semi-arid sugar lands surrounding Pearl Harbor" (Larrison, 1916, 81).

Information about the tunnel construction.

"The tunnels connect up to the various streams on the North side, and take in the water at the adits in the gulches. The number of adits at which water is taken in is 30, the intakes being located at the most advantageous points at the streams in the gulches" (Kluegel, 1916, 6)

"The water is also delivered into numerous reservoirs, especially at night, when irrigating the cane fields is inconvenient. One of the larger reservoirs, on the line of the Waikakalaua storm water ditch, has long been in use. It is called Five Finger Reservoir. Its elevation was a determining factor in establishing the grade elevation of the Waiahole conduit" (Kluegel, 1916, 6).

Interference by Water

"While it was suspected at the outset that considerable water might be encountered in the main bore through the mountain, it was not anticipated at the beginning that enough water would be developed to materially interfere with the progress of the excavation. This hope was not realized, however, for the main bore had proceeded only about 200 feet from the North portal when water to the extent of two million gallons daily was developed—this on breaking through the first dyke" (Kluegel, 1916, 12).

"The pressure of water in the drill holes interfered very much with the blasting, so that the ordinary methods of charging and firing could not be used. The final expedient resorted to to hold the dynamite in place until it could be fired was to pack the sticks of explosive in thin metal tubes of the diameter of a stick of powder, and of sufficient length to enclose the quantity of powder desired. This scheme gave good results, but was expensive and materially delayed progress" (Kluegel, 1916, 12).

"When the water had increased to the point where it could not be drained out by gravity by lowering the floor at the North portal, a siphon pipe made of redwood, and 16 inches in diameter, was installed, and this made it possible to drive the work ahead a short distance further.

"This alternate working was continued to 1700 feet from the North portal, where a chamber was blasted out of the solid rock on the side next to the relief tunnel. A cross-cut was made to connect the two, and a centrifugal pump of 13 million gallons capacity was installed, which raised the water of the main tunnel through a pipe to the relief tunnel,

which, at this point, is some 18 feet higher, and the relief tunnel acted as a drain" (Kluegel, 1916, 14).

Early in November, 1914, the flow began to decrease and this decrease has continued more or less gradually until on November 20, 1915, it reached about eight million gallons daily, which is but two million gallons per day in excess of the former low water flow from the Waiahole springs. This flow measured about the same until January 26, 1916, when the last measurement was made" (Larrison, 1916, 83).

"In order to give room for the water to flow from the heading the track was raised on timbers of 4x12 in long lengths, place edgewise as stringers, on top of which the track ties were laid. The track was 24" gage, laid with 16-pound and 20-pound T-rail. The cars used were the standard Koppel one-yard, all-steel dump cars. Electric locomotives driven by storage batteries were used in both headings. These gave good service on short hauls, except for the necessity of frequent recharging of the batteries, and minor difficulties due to water" (Kluegel, 1916, 16).

"A gasoline motor tractor was used for the long haul, until the track was raised in the South heading, the raising of the track leaving insufficient clearance for the gasoline locomotive" (Kluegel, 1916, 16).

"A cable haul was then installed, this operating entirely without interruption from the water and clearance. The steel cable used was one-half inch in diameter, and was approximately four miles in length, spliced to make a continuous cable, and running over a sheave secured to a timber in the floor of the tunnel at 10,800 feet from the South portal. The cable tractor was a double-drum puller with a cable tightener, and was driven by belt and gearing from a 50 H.P. electric motor. There was

considerable wear on the cable, due to abrasion on the ties. This wear was much reduced by damming up the water in the tunnel at frequent intervals in order to permit the cable to run in the water, which, apparently, acted as a lubricant and reduce the wear. The cable parted on two occasions, and delayed the work until a splice could be made. One cable was completely worn out and the second cable used was probably about half worn out, over a period of eight months" (Kluegel, 1916, 18).

"Mr. Jorgensen states that the average cost of the north end of the main tunnel was about $100 a foot, owing to the expense of drainage. The two bores met at 11,679 feet from the south portal on December 13, 1915. The Oahu Plantation was in dire need of the water at the time; otherwise a good deal of money could have been saved by allowing much of the stored water to drain out by gravity" (Stearns, 1935, 401).

Appendix 5

Volume 11 Number 5 (November 2000)

Chronology of Waiahole Ditch

1913-1916: Waiahole Water Co., Ltd., constructs the Waiahole Ditch. The cross -Ko`olau tunnel alone is 2.76 miles long. Drilling of "developmental tunnels" to feed into the system did not cease until 1963. By the 1990s, the ditch was delivering about 27 million gallons a day on average to leeward O`ahu.

July 1992: The Commission on Water Resource Management designates windward O'ahu as a water management area. Within one year, all users of windward groundwater are required to apply for water use permits.

June 1993: O`ahu Sugar Co. submits five applications for use of up to 24.6 million gallons a day from the Waiahole Ditch and its feeders. The use was "primarily for sugarcane cultivation."

August 1993: Amfac, parent company of O`ahu Sugar and Waiahole Water Co. (now known as Waiahole Irrigation Co., or WIC) announces plans to shut down plantation operations.

November 1993: State Department of Agriculture files a request with the Water Commission to "reserve" all the water in Waiahole ditch for agricultural purposes.

December 1993: Kahalu`u Neighborhood Board No. 29, Waiahole-Waikane Community Association, and the Hakipu`u Ohana petition the Water Commission to restore flows in windward streams from Kualoa south to He`eia. The petition was expanded in April 1994 to include restoration of flows in Kahana Stream. The commission determined the petition was complete; the deadline for acting on the petition was set at December 19, 1994.

June 1994: Amfac submits revised applications for water use, with intended use identified as "diversified agriculture

and irrigation for planned and existing urban development in central and leeward O`ahu." The state Department of Land and Natural Resources joins as "co-applicant." The petition is deemed incomplete.

October 1994: The parties to the Waiahole dispute enter a process of mediation. More than a dozen claimants to the water participate. Mediation fails to resolve issues; a contested case hearing is approved.

December 1994: The gate at the head of Waiahole Stream is opened and about 14 million gallons a day are restored to the stream, under terms of a six-month agreement worked out though mediation.

June 19, 1995: As the expiration of the agreement approaches, Amfac announces plans to reduce stream flows. Protesters gather at the head of Waiahole Stream.

June 21, 1995: Attorney General Margery Bronster and Waiahole Irrigation Co. are granted a restraining order allowing for the removal of protesters.

June 23, 1995: Amfac announces it will not increase the flow in the ditch until the Water Commission has a chance to extend the interim agreement.

June 30, 1995: The Water Commission directs that 9.4 million gallons a day flow into the trans-Ko`olau tunnel of the ditch, while the remaining water is to flow into Waiahole Stream. With an additional 4 mgd of water collected in the tunnel itself, leeward flow in the ditch is around 13 mgd. The base flow in Waiahole stream, which has been about 3 mgd before December 1994, is now about 16 mgd.

November 1995: The contested case hearing opens.

November-December 1995: *Environment Hawai`i* reports conflicts of interests involving Water Commissioner Herbert "Monty" Richards in the Waiahole case. Richards is part-owner of two companies leasing land from Campbell Estate, a party in the contested case, he has entered into a development agreement with the Gentry Companies, another party with an interest in the decision; and one of his

companies, Kahua Ranch, had gone on record with testimony in 1994 favoring leeward uses of Waiahole water.

January 1996: Commissioner Richards rescues himself from participation in the Waiahole contested case. No reason is given.

August 21, 1996: Testimony in the Waiahole contested case is completed, after 52 hearing days, four evening sessions, testimony from 161 witnesses, and 567 exhibits admitted into evidence.

July 1997: The Water Commission releases a proposed decision. In arguments before the commission, Attorney General Margery Bronster, representing the state Department of Agriculture, testifies in opposition to the proposal drafted by Deputy Attorney General Bill Tam, assigned to the Water Commission.

September 1997: Deputy Attorney General Tam is dismissed by Bronster.

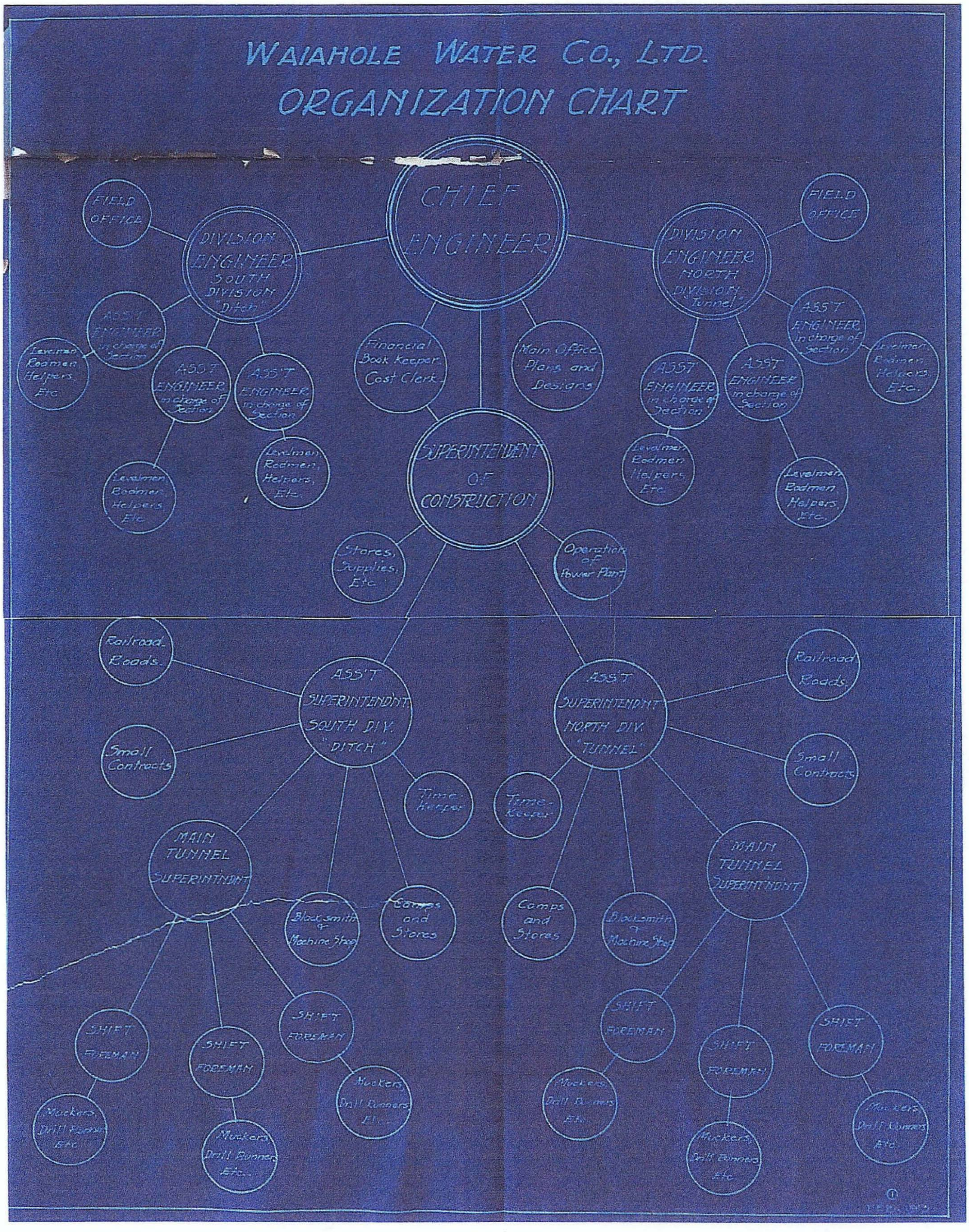
December 1997: The Water Commission issues a 250-plus page ruling in the contested case. The final decision differs from the proposed one, in that it has increased the amount of water distributed to leeward parties by 3.8 mgd.

January 1998: The decision is appealed to the Supreme Court.

July 1998: The state Agribusiness Development Council acquires Waiahole Ditch.

August 22, 2000: The Supreme Court issues its ruling.

Appendix 6


WAIAHOLE WATER CO., LTD.
ORGANIZATION CHART
CHIEF ENGINEER
DIVISION ENGINEER SOUTH DIVISION "Ditch"
FIELD OFFICE
ASS'T ENGINEER in charge of Section
Levelmen Rodmen Helpers Etc.
ASS'T ENGINEER in charge of Section
Levelmen, Rodmen, Helpers, Etc.
Financial Book keeper Cost Clerk
Main Office Plans and Designs
DIVISION ENGINEER NORTH DIVISION Tunnel
FIELD OFFICE
ASS'T ENGINEER in charge of Section
Levelmen Rodmen Helpers Etc.
ASS'T ENGINEER in charge of Section
Levelmen Rodmen Helpers Etc.
SUPERINTENDENT OF CONSTRUCTION
Stores, Supplies, Etc.
Operation of Power Plant
Railroad Roads
Small Contracts
ASS'T SUPERINTENDENT SOUTH DIV. "DITCH"
Time-keeper
MAIN TUNNEL SUPERINTENDENT
Blacksmith & Machine Shop
Camps and Stores
SHIFT FOREMAN
Muckers, Drill Runners Etc.
SHIFT FOREMAN
Muckers, Drill Runners Etc.
SHIFT FOREMAN
Muckers, Drill Runners Etc.
Railroad Roads
Small Contracts
ASS'T SUPERINTENDENT NORTH DIV. "TUNNEL"
Time-keeper
MAIN TUNNEL SUPERINTENDENT
Camps and Stores
Blacksmith & Machine Shop
SHIFT FOREMAN
Muckers, Drill Runners Etc.
SHIFT FOREMAN
Muckers, Drill Runners Etc.
SHIFT FOREMAN
Muckers, Drill Runners Etc.

Appendix 7

FINAL

PROGRESS

REPORT

OF

H. K. BISHOP

ON

THE KOOLAU TUNNELS.

FINAL REPORT.

To the President and Directors of the

Waiahole Water Company, Limited.

Gentlemen:-

I beg to submit the following final report:

PROGRESS:

Since the last report, dated August 1st, 1913, we have driven 487 feet of side tunnels on the North side, and 158 feet of side tunnels on the South side.

On the main tunnel, we have driven 338 feet on the north side, and 601 feet on the south side, making a total of 912 feet on the north side, and 2063 feet on the south side completed.

PLANT AND MACHINERY.

So far as I know, the only machinery which has been ordered, but has not reached here as yet, consists of two blowers for the Main Tunnel. There is also an order in for a few locomotive spare parts and some extras for the Leyner Drills. There is also an order in for pulleys for both machine shops, with the Honolulu Iron Works Company.

Outside of the above items I believe that everything is here.

BILLS.

The only outstanding bills are those of the Oahu Sugar Company, Limited, for freight and labor and material in connection with the Power Plant; Eben Low and the "HEWA MARU" for freight; and bill for telephone rental.

Outside of the above, there are a few miscellaneous small bills which are coming in from time to time, and which are being forwarded to H. Hackfeld & Co., Ltd., for payment as fast as we are able to collect them. There will also be the salary payments of the men held over after October 1st.

TELEPHONES.

The following telephones are now in use by the Company:

1 at the Honolulu Office,

1 at the City Warehouse,

2 at Waiahole - (1 at the main camp and 1 at the Tunnel camp),

2 at Waiawa - (1 at the main camp and 1 at the Tunnel camp).

SURVEYS.

The surveys have been completed for everything excepting the tunnels in Kahana. These surveys have been plotted up for working drawings on each side, and are kept in the field offices. All note books and data relating to such surveys and plans are in the field offices, and can be seen there. Tracings have been made, showing the revised line and grades.

ENCLOSURES.

I am submitting herewith full tabulated reports showing distances excavated on all tunnels, etc.

Hoping that the Inventory, Statements and final report herewith submitted will contain all the data you may wish for future reference, and trusting that you will have every success in the new manner of handling the work, I am,

Respectfully,

W. R. Bishop

CHIEF ENGINEER.

HONOLULU, T. H.

October 1st, 1913.

Appendix 8

Electric Power systems

"At the outset it was planned by Mr. Bishop to supply electric power to the two portals for operating the air compressors and other machinery from a central power station, located at Pump 6, transmitting at high voltage by pole line to the two portals, the pole line extending past the South portal over the mountain to the North portal" (Kluegel, 1916, 18).

"This station was installed and the power line was built form Pump 6 as stated, but before it was completed, water had been struck on the North side, and the quantity was found to be sufficient to supply all the power needed, the available convenient hydraulic head being approximately 250 feet. The central steam-driven power plant was completed, however, and held at reserve for emergency use, although the plant and power line from Pump 6 to the South portal was used very little. The central power plant consisted of 500 H.P. Babcock & Wilcox water-tube boilers, supplying steam at 180 lbs. pressure, to a 350 K.W. high-pressure non-condensing steam turbo generator set, delivering 3-phase current 3300 volts pressure, stepped up and transmitted at 11,000 volts to the two stations at the portals, and there stepped down to 250 volts for use at the motors. Oil fuel was used for the boilers, and the location at Pump 6 was chiefly on account of the convenience of fuel

supply, which was drawn for the tanks supplying fuel to the boilers at Pump 6" (Kluegel, 1916, 18).

"The plant which actually supplied the power for use at the tunnel was a 350 H.P. Pelton water-wheel belted to 300 K.W. 3-phase generator, these units being installed in the gulch below and near the North portal" (Kluegel, 1916, 18).

"There was an abundance of water from the North heading, and the head at the Pelton wheel was 250 feet. This made an inexpensive and easily operated plant which was entirely satisfactory except at rare intervals when the water was low. The power was transmitted by pole line to the South portal in the opposite direction to that originally planned" (Kluegel, 1916, 18).

Appendix 9

Historic papers lost in fire

Honolulu Advertiser FRIDAY • APRIL 2, 1999

Waipahu blaze arson, officials say

By Scott Ishikawa
ADVERTISER CENTRAL BUREAU

WAIPAHU — Historical photographs and documents — including accounts by plantation workers who watched Japanese planes attack Pearl Harbor — were lost when an Oahu Sugar Co. office building burned early yesterday.

Fire investigators say arson caused the fire at the old Waipahu Sugar Mill site.

Tamara Edwards, president of Amfac/JMB Hawaii's real estate division, said many of the lost pictures and papers recorded the history of the Waiahole Irrigation Co. The Amfac subsidiary helps operate the Waiahole Ditch, which transports irrigation water from Windward Oahu to the Leeward and Central parts of the island. Some of the documents dated from the 1900s.

Amfac employee Lynn Owan said the accounts of the 1941 Pearl Harbor attack were thought to have been stolen during a Thanksgiving break-in, but eventually were found in a different location and stored at the company office.

"Now they're really gone," said Owan, who was sifting through charred documents yesterday.

But Oahu Sugar Co. employee Elmer Nii, who supervises the site, said he would check to see if he had copies of the Pearl Harbor accounts at his home.

Firefighters responded to the blaze off Waipahu Street at 12:30 a.m. and had it under control 20 minutes later. Damage was estimated at $120,000 to the building and $20,000 to its contents.

"Nearly all of them are gone," Edwards said of the Waiahole Co. files. "Fortunately, we had moved from the building many of the documents and historical items that pertained to Oahu Sugar Co."

Edwards said the sugar company records and artifacts had been transferred to other Amfac offices or donated to the nearby Hawaii Plantation Village museum.

Fire investigator Lance Orillo said a flammable liquid had been spilled at the 880-square-foot building, causing investigators to believe the fire was no accident.

Nii said he learned about the fire from television yesterday morning.

"I looked at the screen and said, "That can't be my office,'" said Nii, a company employee since 1980.

The remains of the burned building was demolished yesterday afternoon as a safety precaution.

Oahu Sugar Co. ceased production in 1995.

Appendix 10

Articles from

Environment Hawai'i a monthly newsletter

1. Oahu Faces Costly Solutions to Water Woes
   Vol. 13 Num. 11 May 03

2. Court's Waiahole Decision 'Inspiring' Says Public Trust Expert Jan Stevens, Vol. 12 Num. 8 Feb 02

3. Final Decision in Waiahole Case Changes Little for Windward Streams, Leeward Farmers Vol. 12 Num. 8 Feb 02

4. Water Commission, Despite Itself, Approves Kamehameha Schools' Offer to Restore Streams Vol. 12 Num. 10 April 02

5. Waiahole Parties Contest Transfer Of Campbell Permit to City BWS
   Vol. 11 Num. 8 Feb 01

6. Water Commission Has Lost Its Way (Editorial)
   Vol. 11 Num. 11 May 01

7. Parting the Waters: Supreme Court Throws Waiahole Dispute Back to Water Commission Vol. 11 Num. 5 Nov 00

8. Chronology of Waiahole Ditch
   Vol. 11 Num. 5 Nov 00

9. State Rates Encourage Use of Waiahole Water
   Vol. 11 Num. 5 Nov 00

10. Waiahole Decision Highlights
    Vol. 11 Num. 5 Nov 00

11. Draft Water Plan Projects Major Shortages
    Vol. 11 Num. 6 Dec 00

12. Will the Well Run Dry? Climate Change, and Response to it, could affect Islands Water Supplies Vol. 10 Num. 1 July 99

13. Water Commission Issues Final Order In Waiahole Ditch Contested Case, Vol. 8 Num. 8 Feb 98

14. Automatic Approval, Waiahole Ditch Purchase Pass Legislature's Muster, Vol. 9 Num. 1 July 98

15. Island Watch Water Commission Releases Proposed Waiahole Decision, Vol. 8 Num. 2 Aug 97

16. Golf Courses are Accused of Exceeding Allowed Take of Waiahole Ditch Water, Vol. 6 Num. 8 Feb 96

17. Water Commission's Performance Is Faulted by State Auditor Vol. 6 Num. 9 March 96

18. Light at the End of the Tunnel? Waiahole Case Enters Final Phase Vol. 7 Num. 2 Aug 96

19. The New Leeward Food Pyramid: Farmers, Middlemen, and Landowners, Vol. 7 Num. 2 Aug 96

20. Unused Leeward Golf Courses Ignore Commission Order to Stop Waiahole Use, Vol. 7 Num. 2 Aug 96

21. Corporate Owner of Ditch Expects Million-Dollar-A-Year Profits Vol. 7 Num. 2 Aug 96

22. Leeward Parties Stress Recharge Value of Ditch, Discount Reuse of Effluent, Vol. 7 Num. 2 Aug 96

23. Expert Link Stream Flow To Kāne'ohe Bay Productivity Vol. 7 Num. 3 Sept 96

24. Return the Water to Waiahole Editorial Vol. 7 Num. 3 Sept 96

25. Who Will Decide? Vol. 7 Num. 3 Sept 96

26. Benefits to Waiahole Stream Life Are Seen Following Restored Flows, Vol. 7 Num. 3 Sept 96

27. Public Trust Resources At Issue In Dispute Over Waiahole Water Vol. 7 Num. 3 Sept 96

28. State's Position on Waiahole Was Made Over Objections of OSP (office of state planning) Vol. 7 Num. 3 Sept 96

29. Since Blasting of Waiahole Tunnel, Natural Flows May Never Be Restored, Vol. 7 Num. 3 Sept 96

30. WIC, Leeward Farmers Contract For Provision of Waiahole Water Vol. 7 Num. 3 Sept 96

31. Water Commissioner Holds Lease Of Ewa Land from Campbell Estate, Vol. 6 Num. 6 Dec 95

32. Lower Hamakua Ditch Was Part Of Grandiose Design for Valley Vol. 6 Num. 2 Aug 95 (article mentions Jorgen Jorgensen)

33. Waiahole Water: Where Will It Go When Sugar Is Gone? Vol. 5 Num. 3 Sept 94

34. Waiahole Tunnel: A Drain on Windward Resources Editorial Vol. 5 Num. 4 Oct 94

35. Waiahole Framers' 20 year Struggle For Land May Be Nearing an End, Vol. 5 Num. 4 Oct 94

36. In 1912, Waiahole Farmer Sought to Insure 'Plentiful Supply of Water,' Vol. 5 Num. 4 Oct 94

37. Commission Decides on Waiahole Releases Vol. 5 Num 4 Oct 94

38. Leeward Politicians Seek to Enter Contested Case on Waiahole Ditch, Vol. 5 Num. 6 Dec94

39. From Fertile Fields to No-Man's Land: The Transformation of Waikane Valley, Vol. 3 Num. 2 Aug 92

40. Water Leases Tied to Management Plan Vol. 1 Num. 1 July 90

41. A State Water Plan, But No Water Policy Vol. 1 Num. 2 Aug 90

42. A Short Course in Water Rights Vol. 1 Num. 2 Aug 90

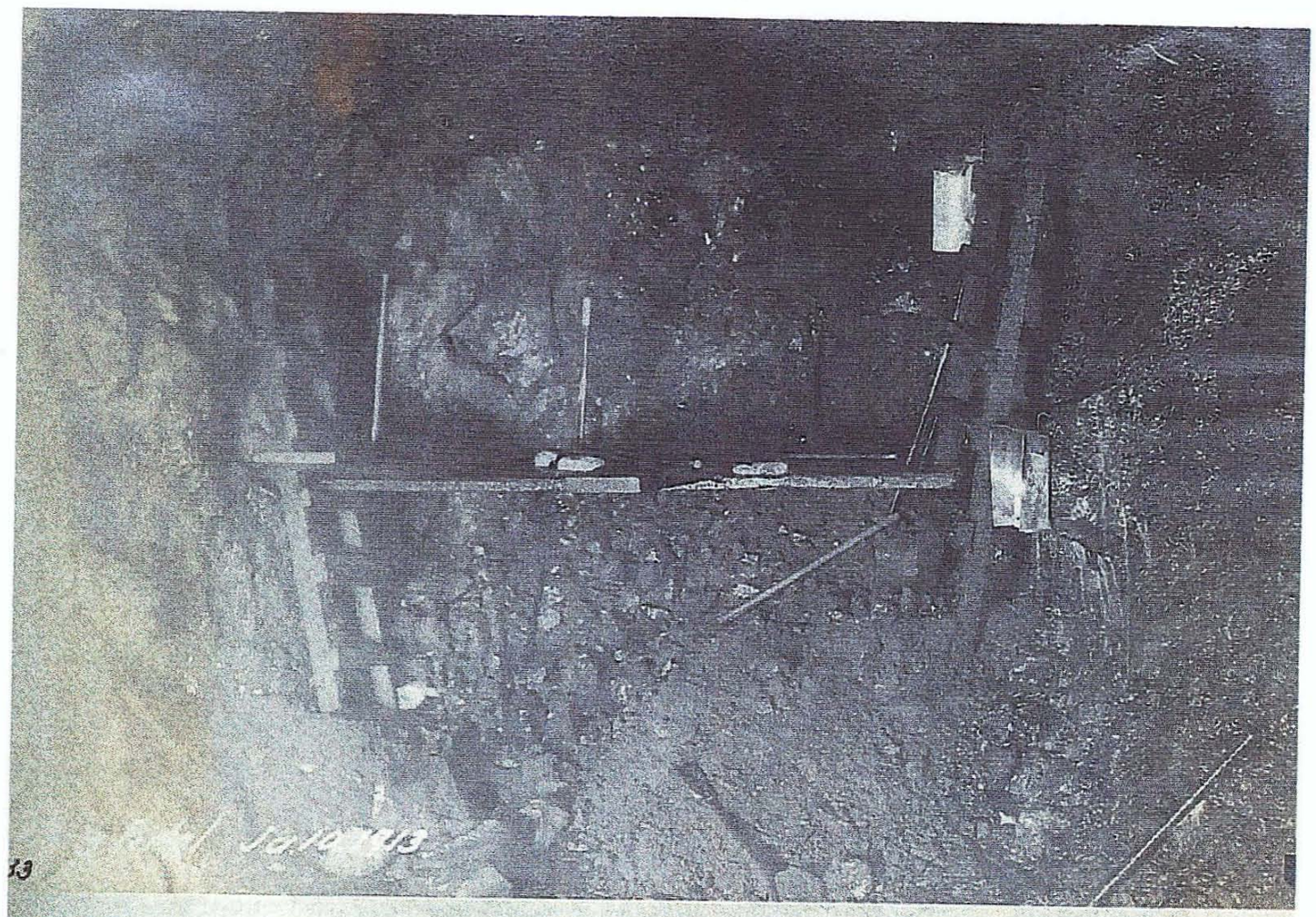
43. The Hawaii Stream Assessment: Report with a Mission
Vol. 1 Num. 2 Aug 90

44. Water Management Areas: Too Little, Too Late?
Vol. 1 Num. 2 Aug 90

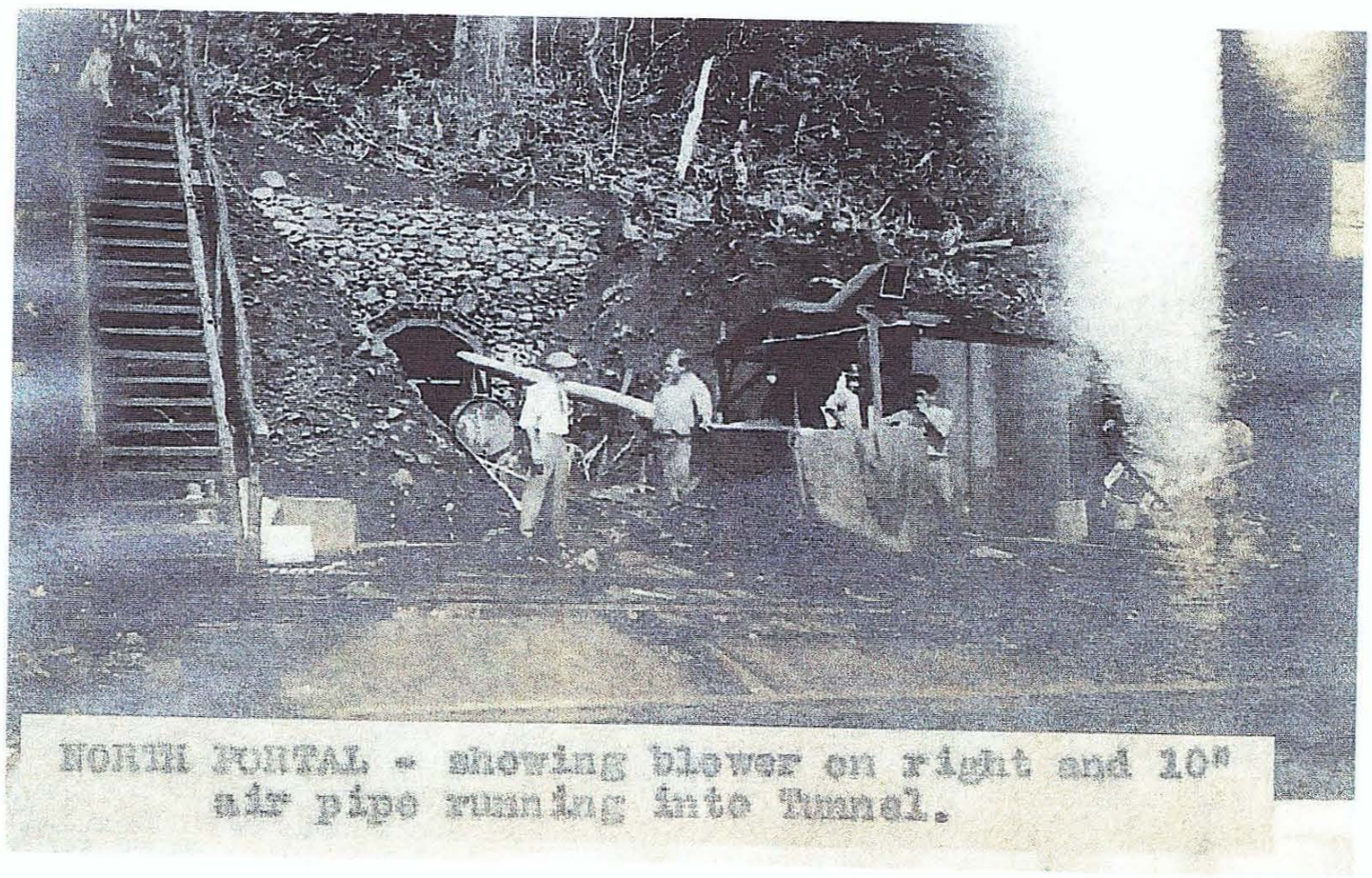
45. Saving Hawaii, Saving Water, Saving the 'Alala
Vol. 1 Num. 6 Dec 90

Windy Point on Koolau Trail between Summit and North Portal, North Division.

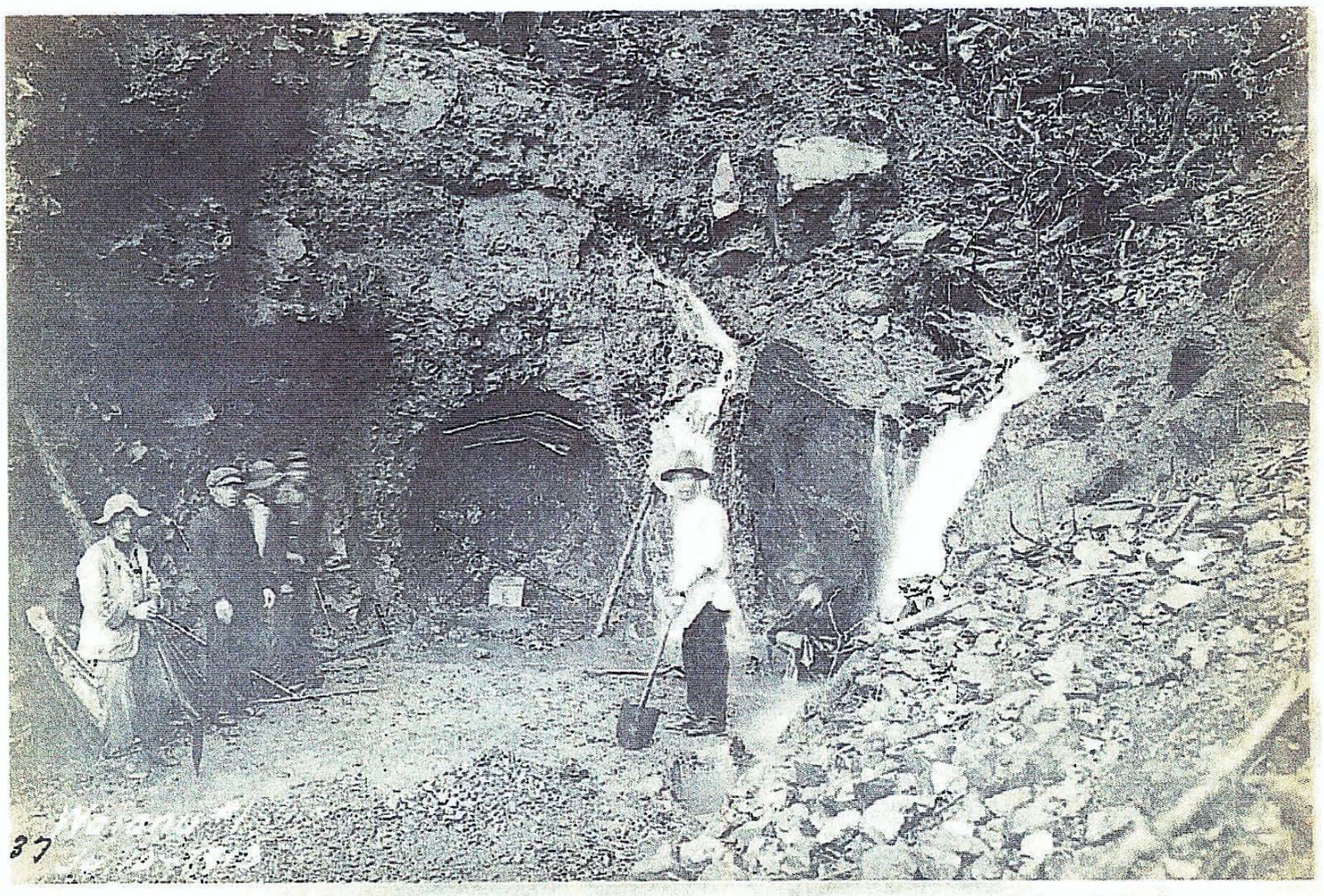
EXCAVATING APPROACH TO NORTH PORTAL- MAIN TUNNEL.



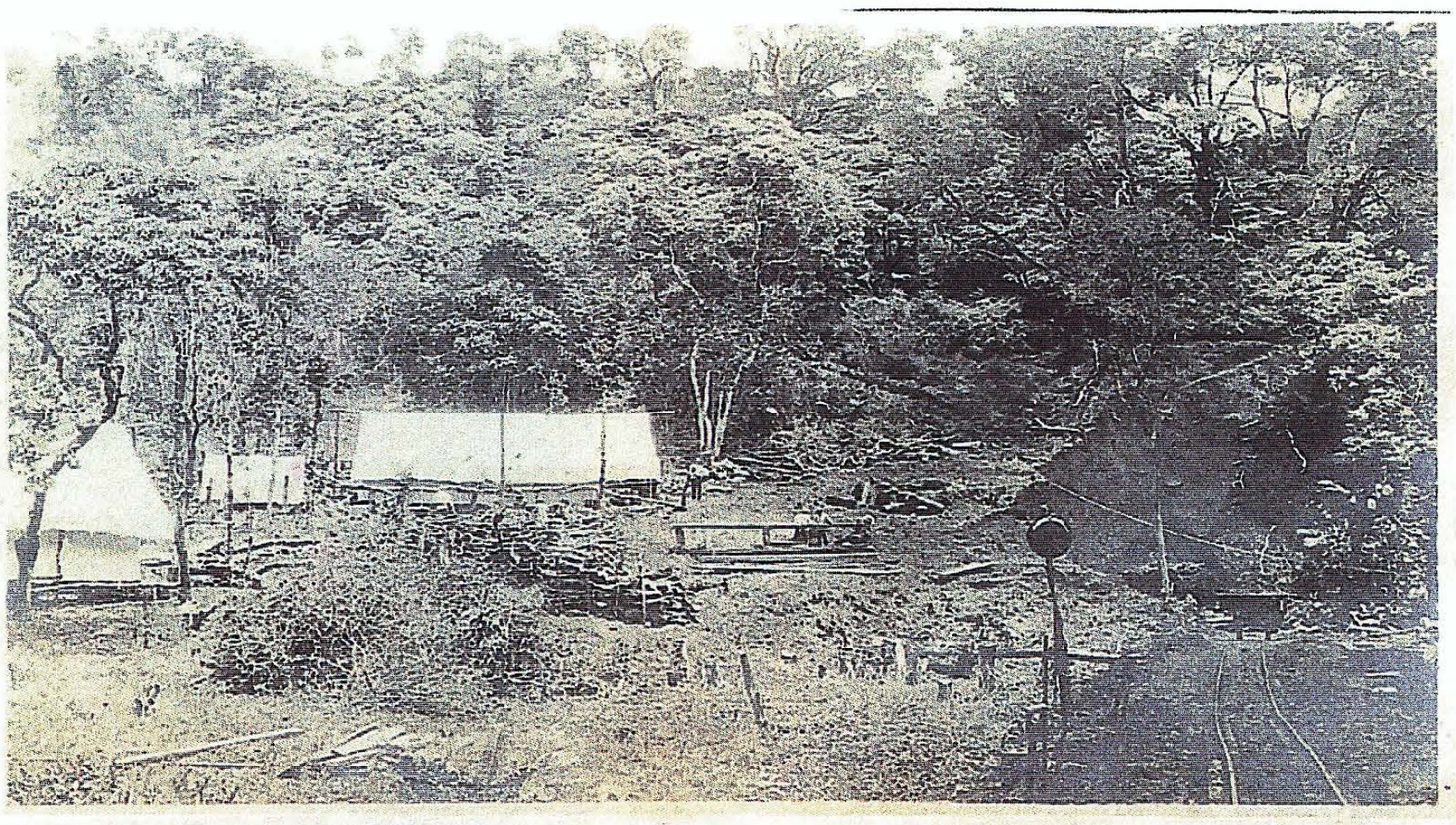
Main Tunnel Heading, North Division, June 10th, 1913 - 326' from Portal.



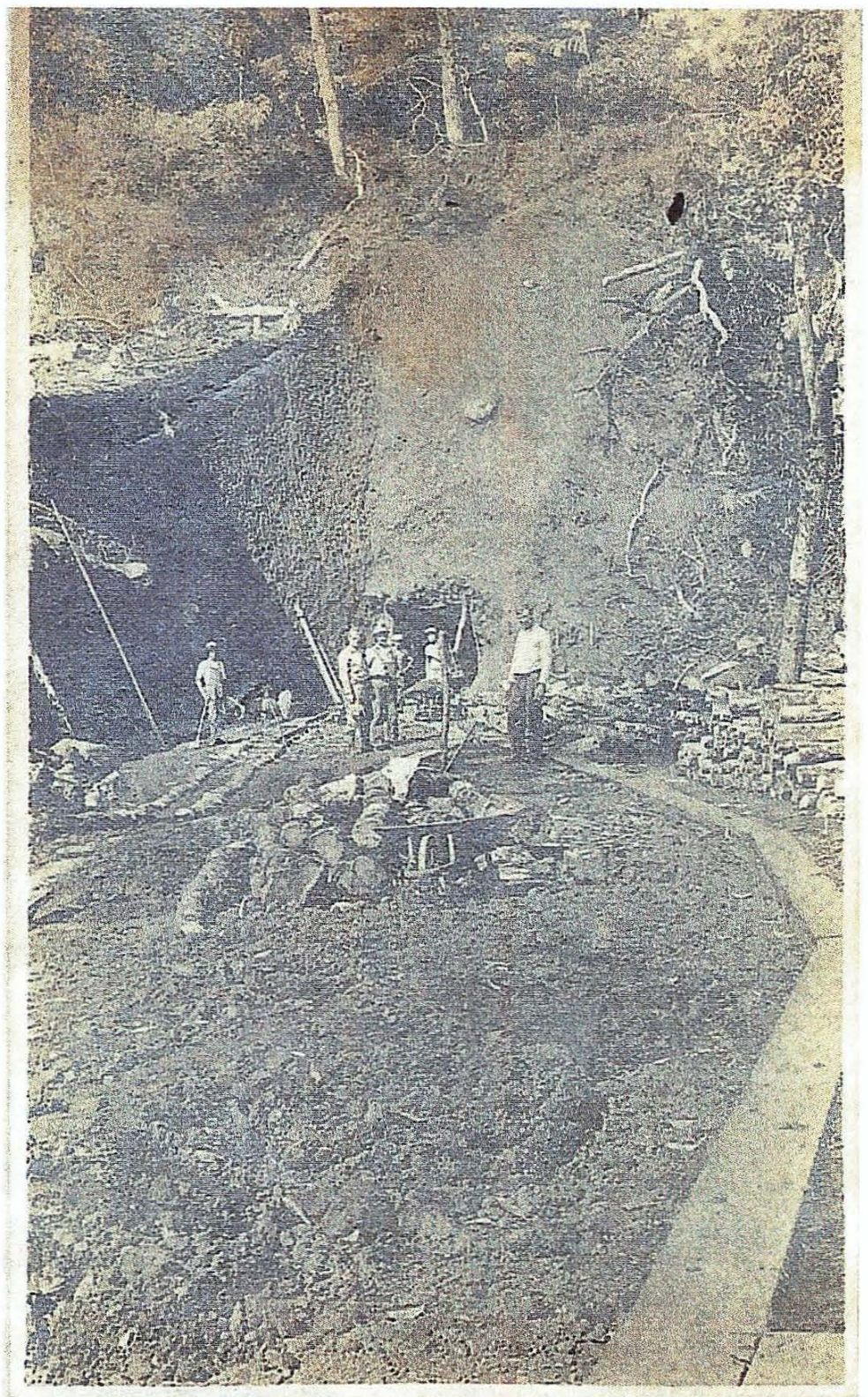
NORTH PORTAL - showing blower on right and 10" air pipe running into tunnel.



Adit 4-5, North Division, as of June 10, 1913.

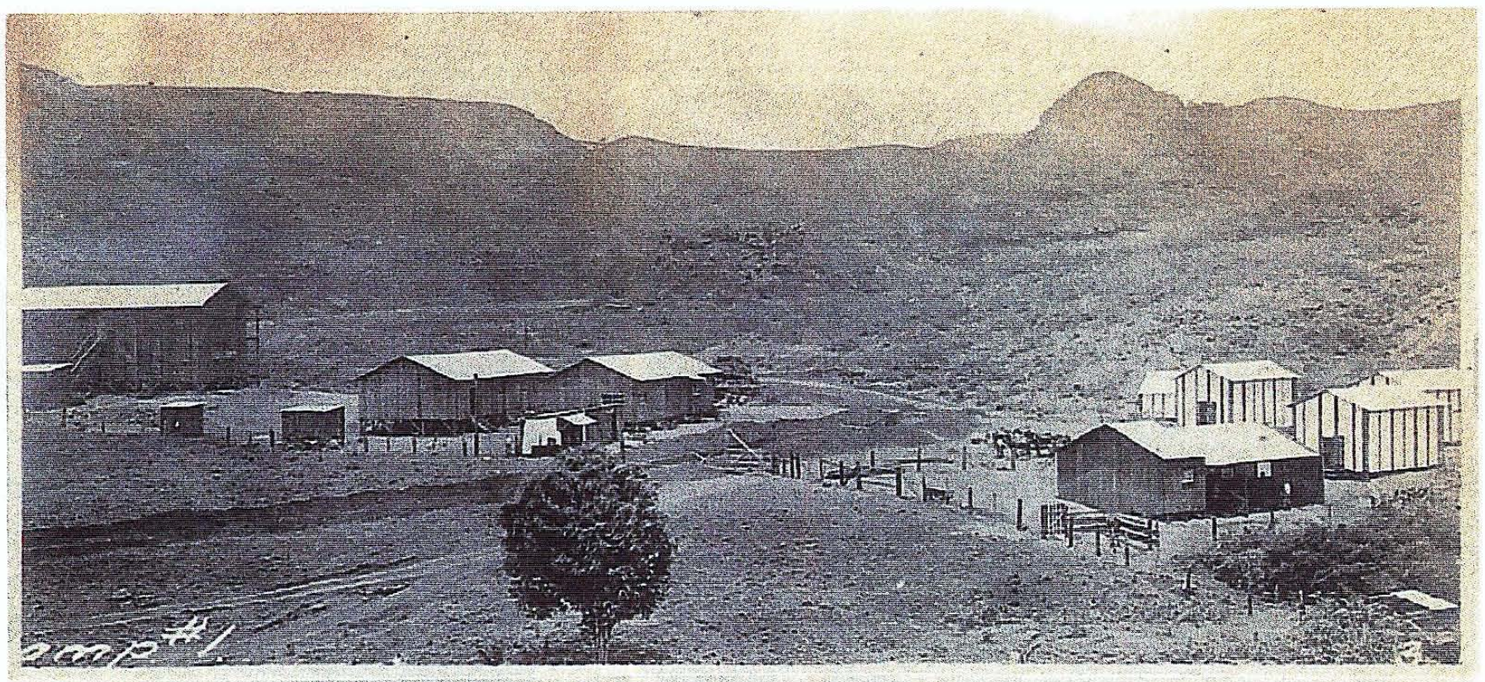


Temporary Camp - Main Tunnel - Showing tunnel portal - South Side.

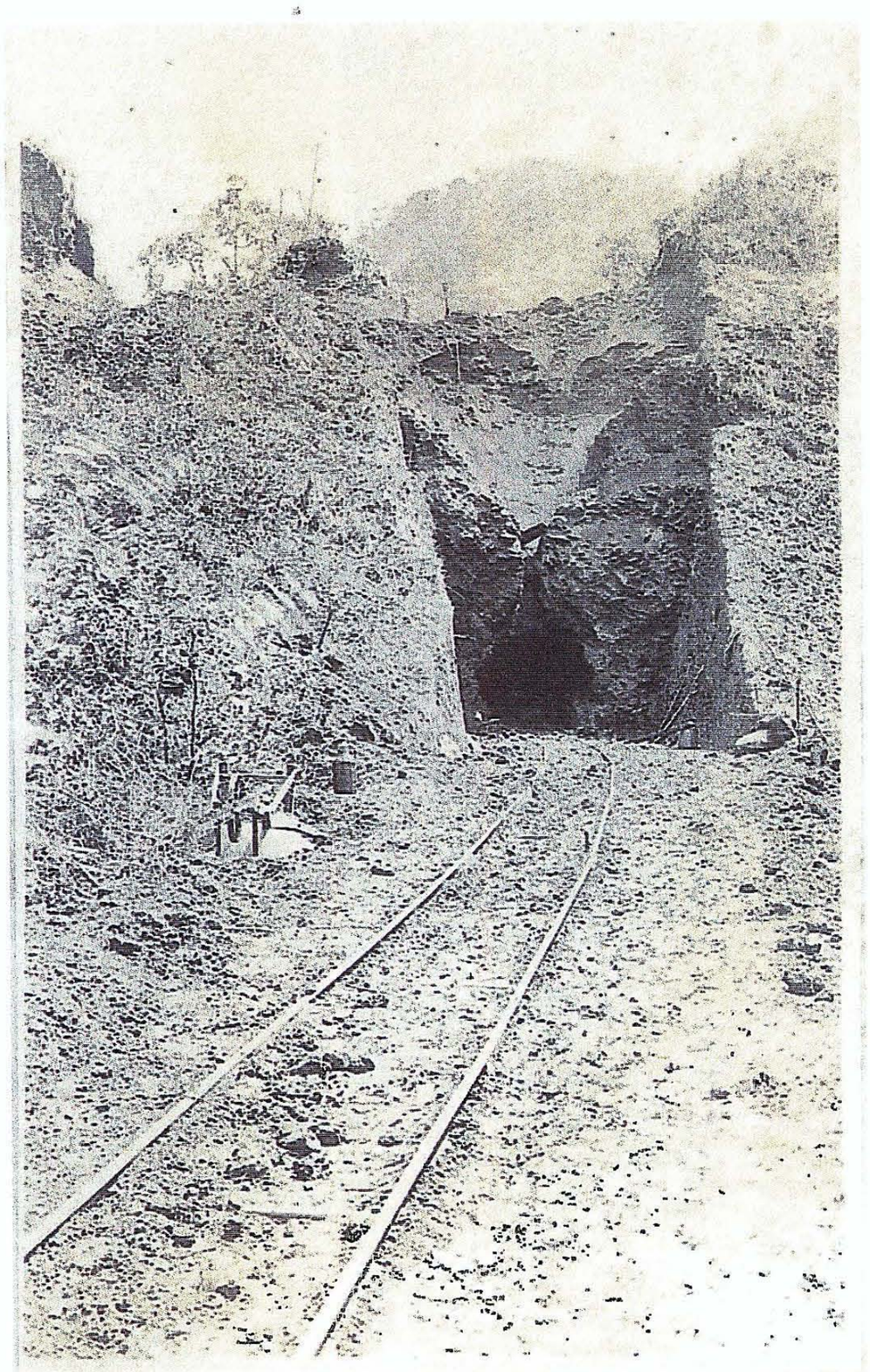


South Portal - Main Tunnel.

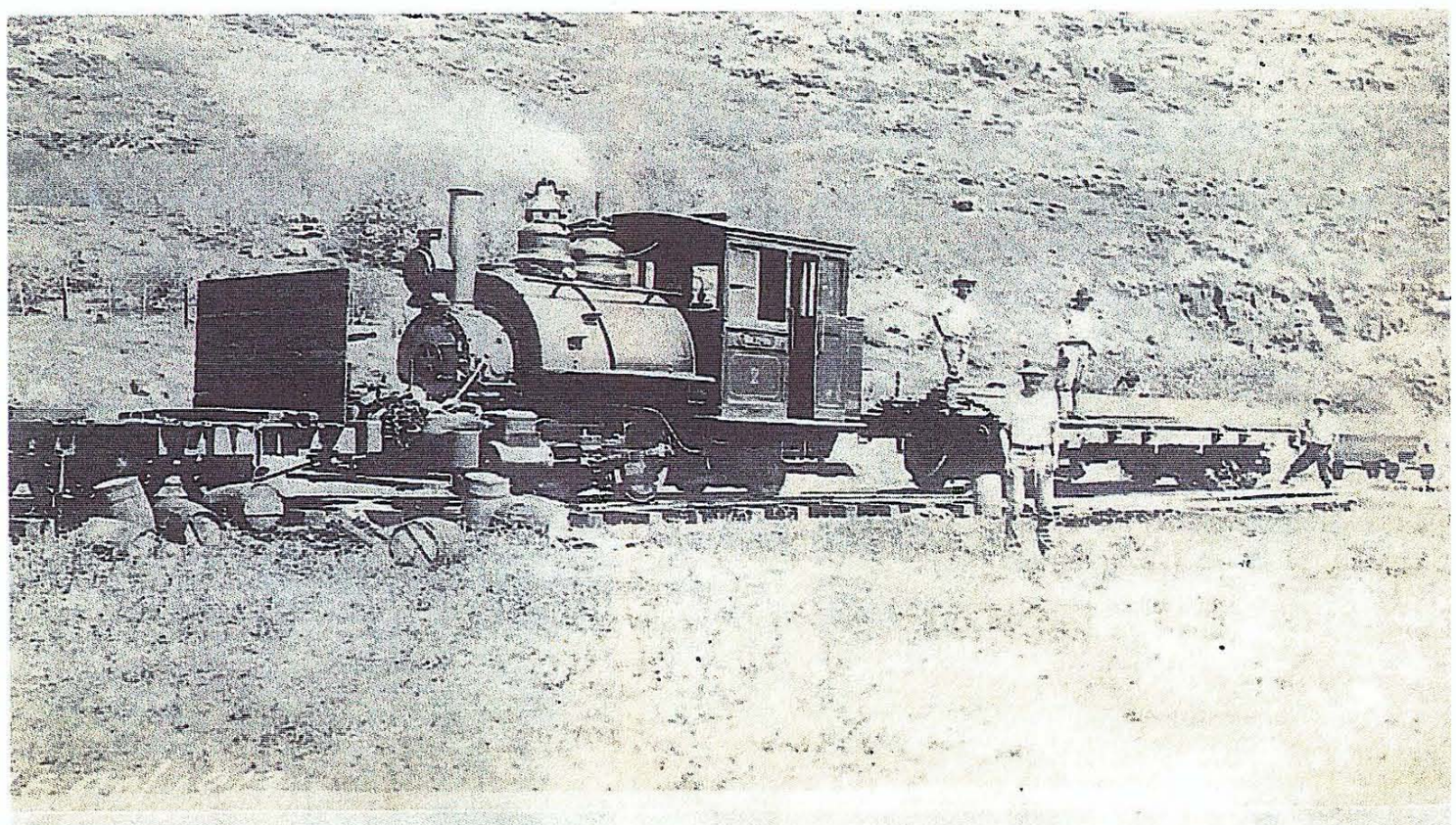
Tunnel Head at a point 400 feet in - South Side.



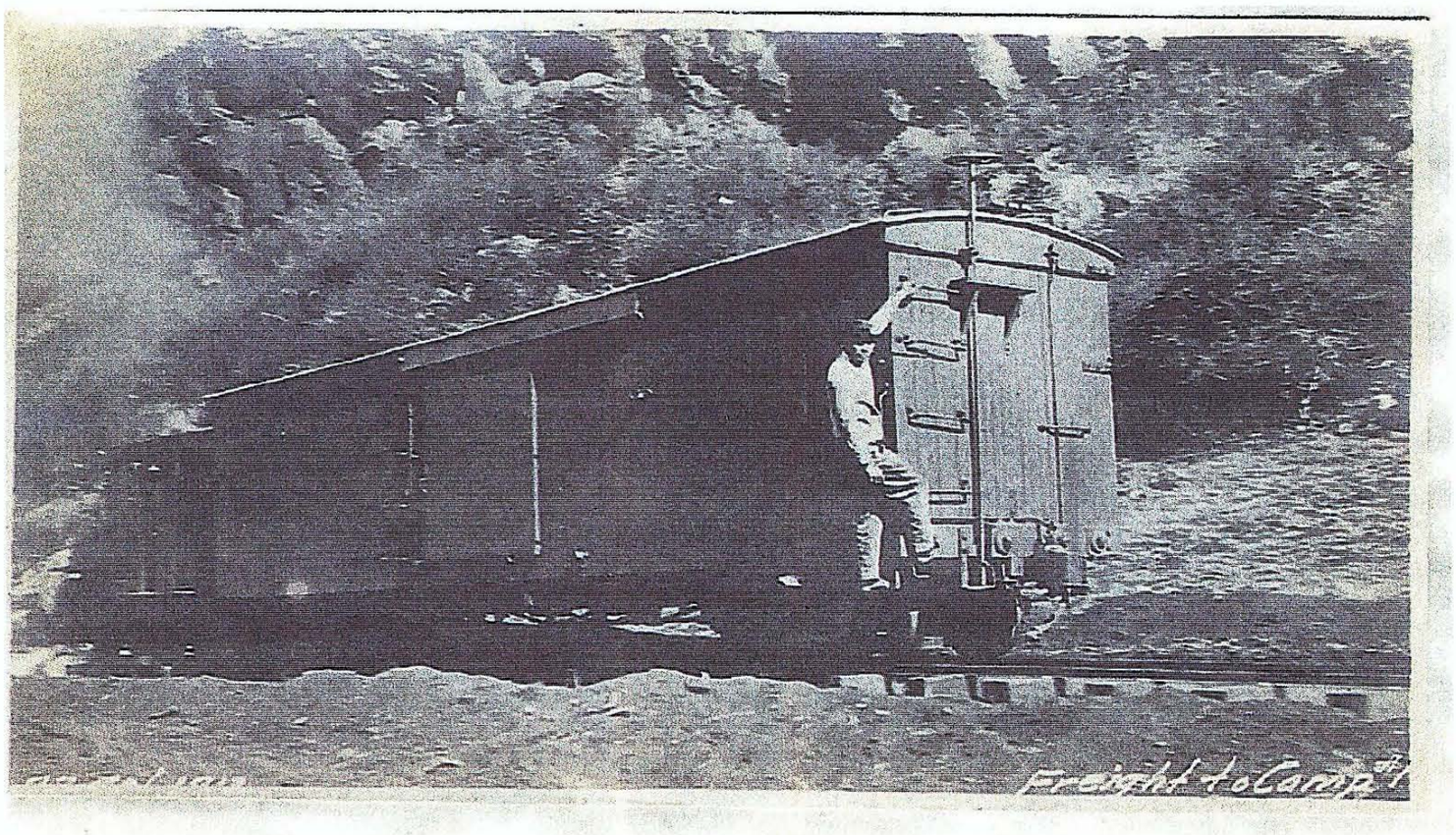
Camp 1 - South Side.



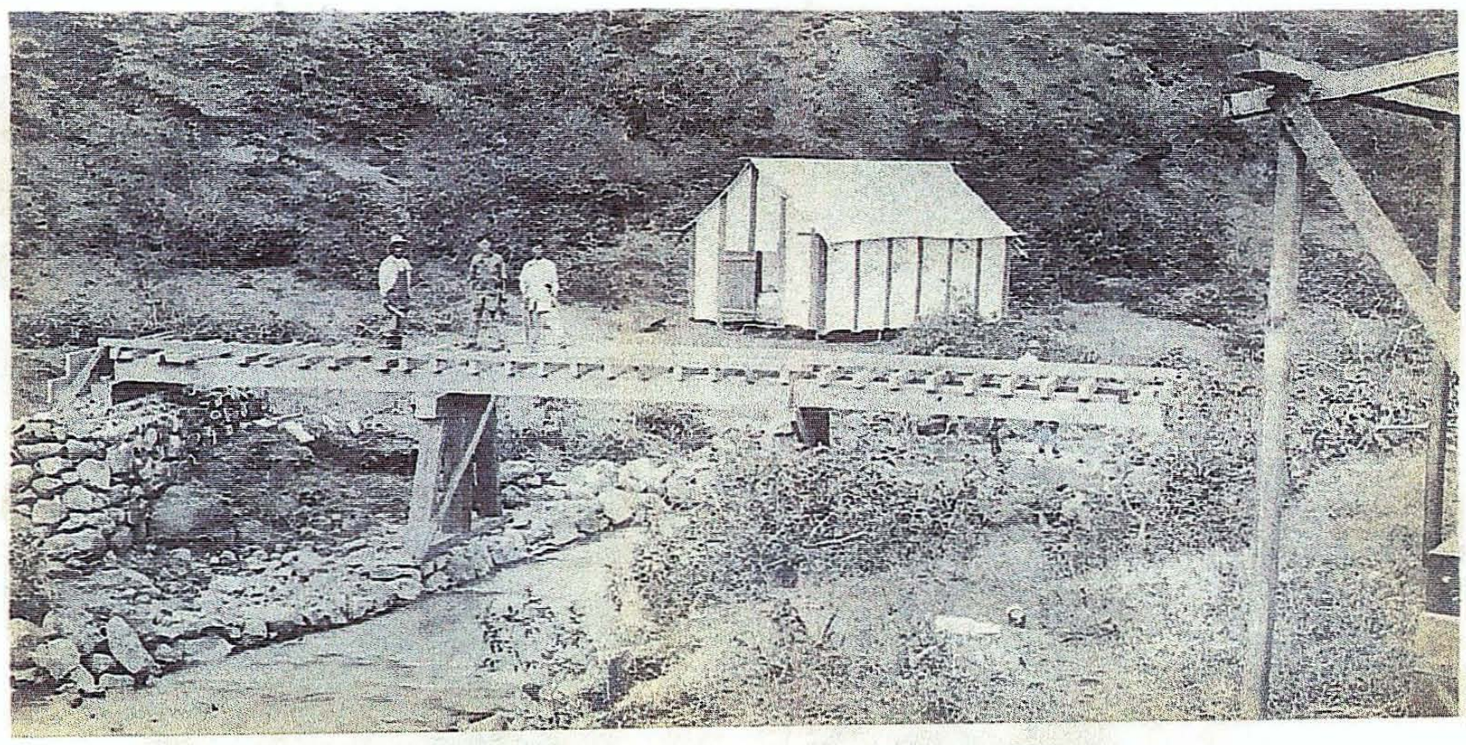
Railroad Cut - South Side.



Load of rails for new Railroad - South Side.



Freight train on way to camp 1 on South Side.

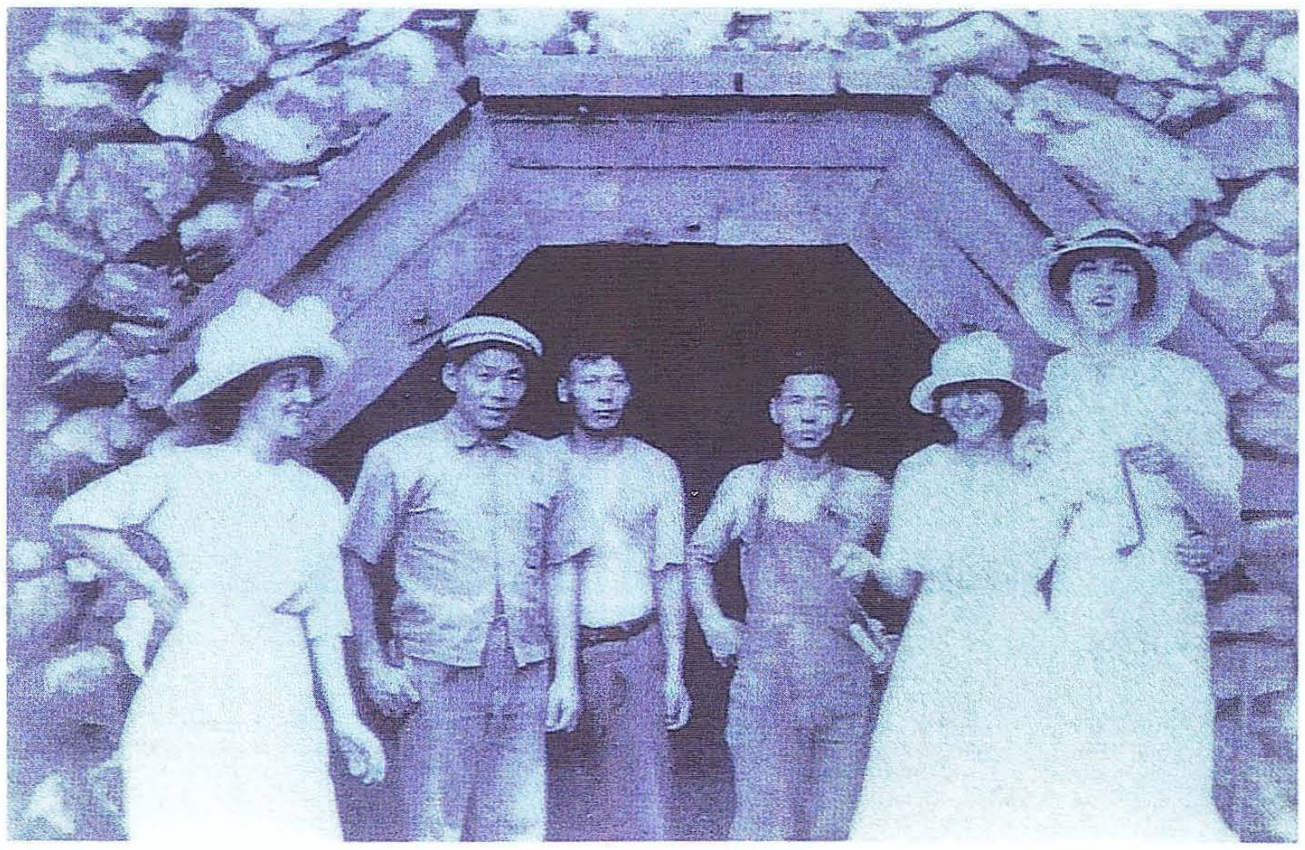


Bridge near Camp 1 - South Side.

Approach to Wakame Wharf, Kaneohe Bay, North Division.

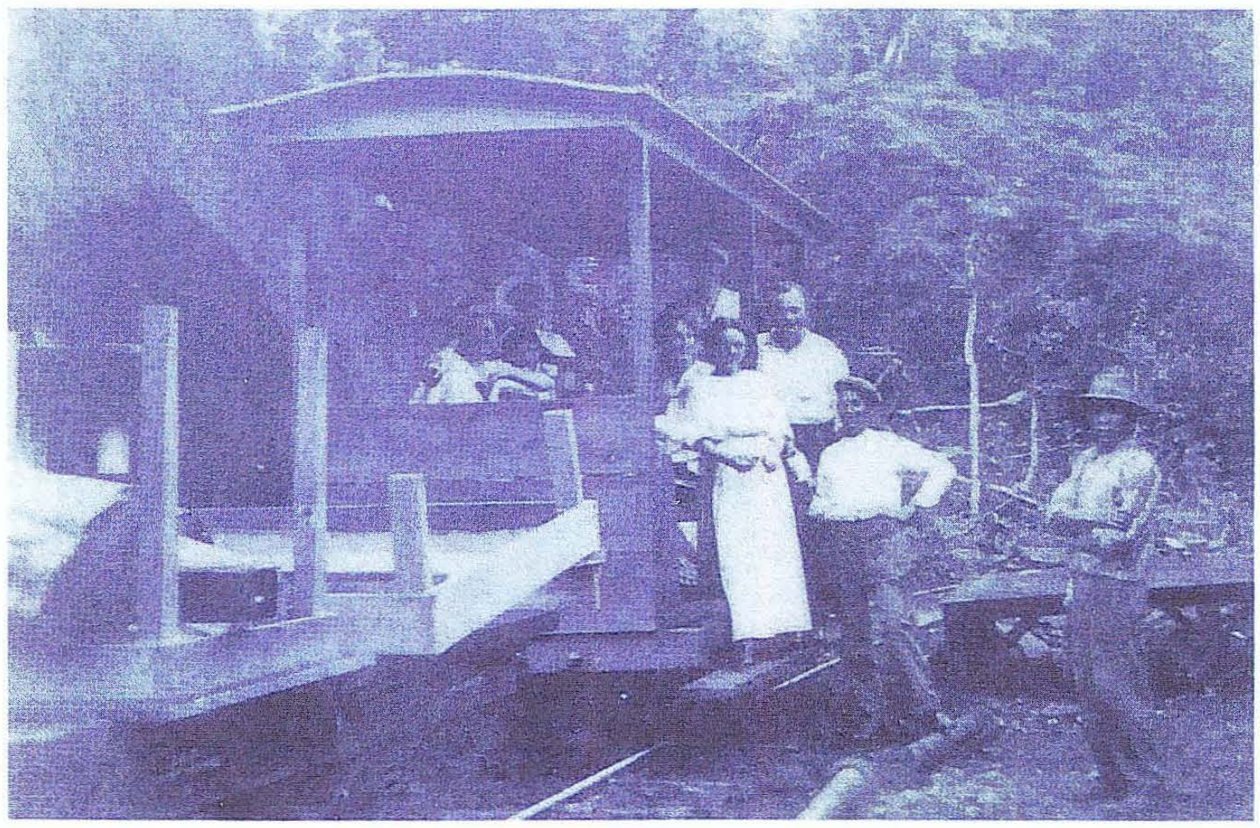
Photographs courtesy of Michael Mauricio

No date or location specified.

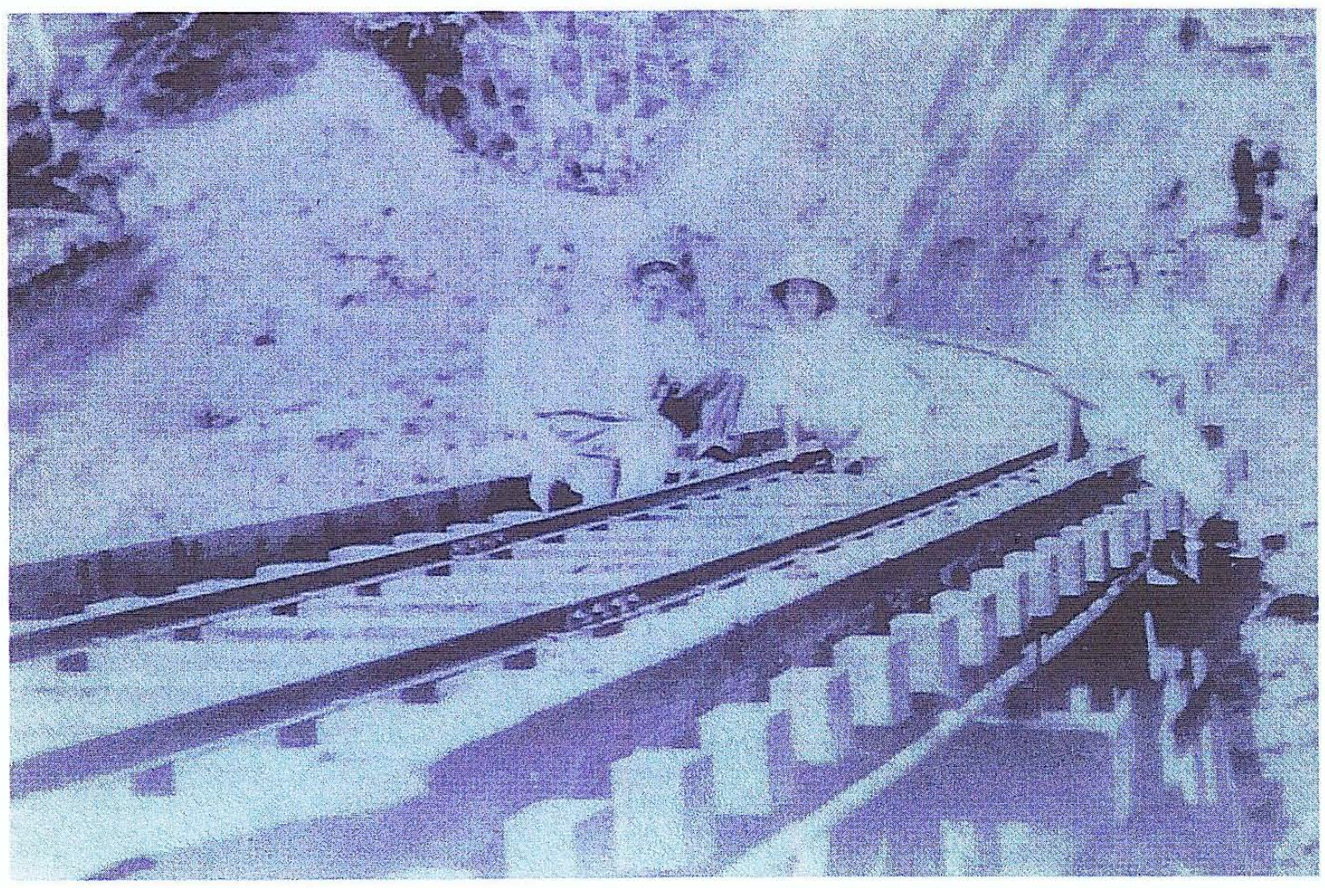


The two ladies on the right are holding candles.

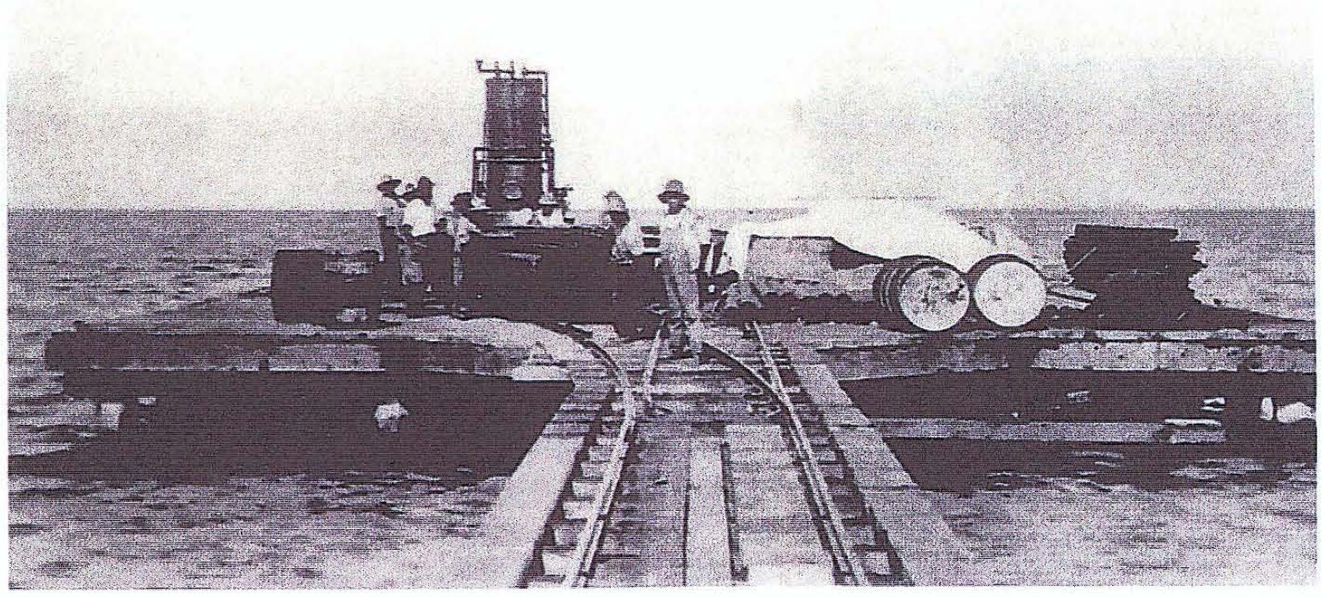
Location unknown although I would speculate
that this is on the windward side.



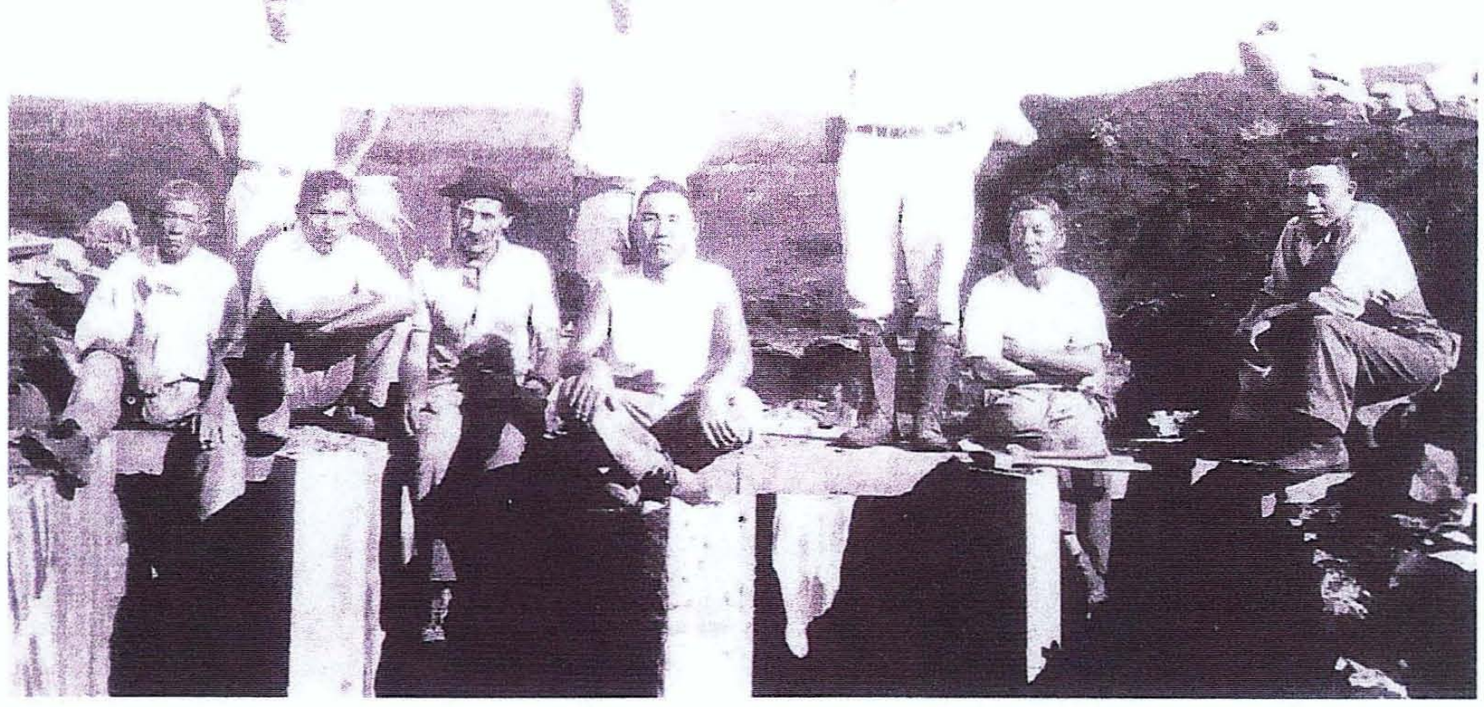
Notice that the train is being used to convey passengers.



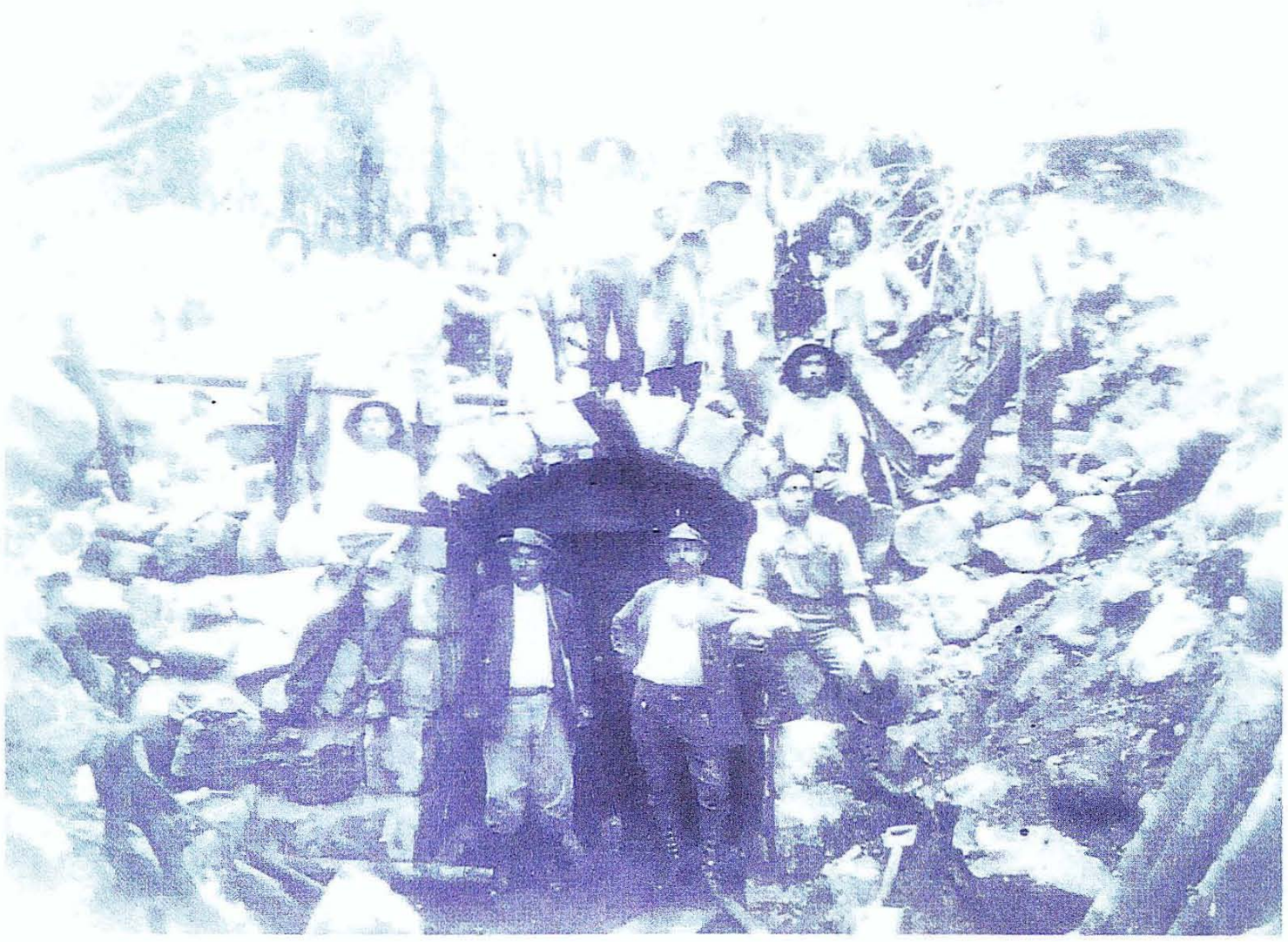
Location unknown.



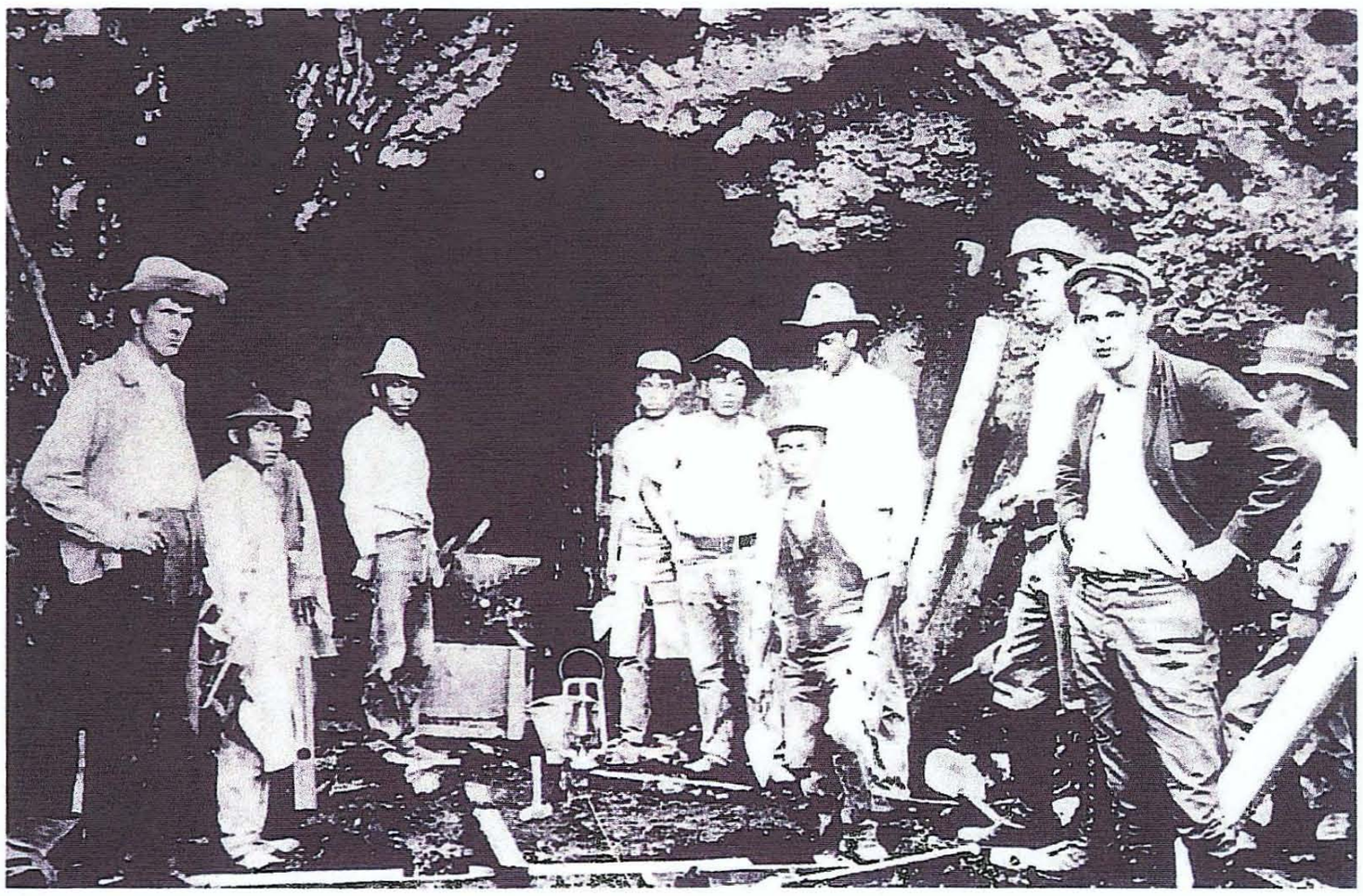
Warf constructed in Kane'ohe Bay for the purpose of bring in supplies and machinery.



Location unknown.



Location unknown.



Location unknown. Notice the kerosene lamps.

Photographs from Dale Hood's on-site visit, March 2004.

Entrance to the North Portal is in the background behind these trees.

Entrance to the North Portal.

North portal entrance; inscription reads WWCo. 1916
(Waiahole Water Company 1916)

This pipe used to carry water to drive the electrical
turbines below the North portal.

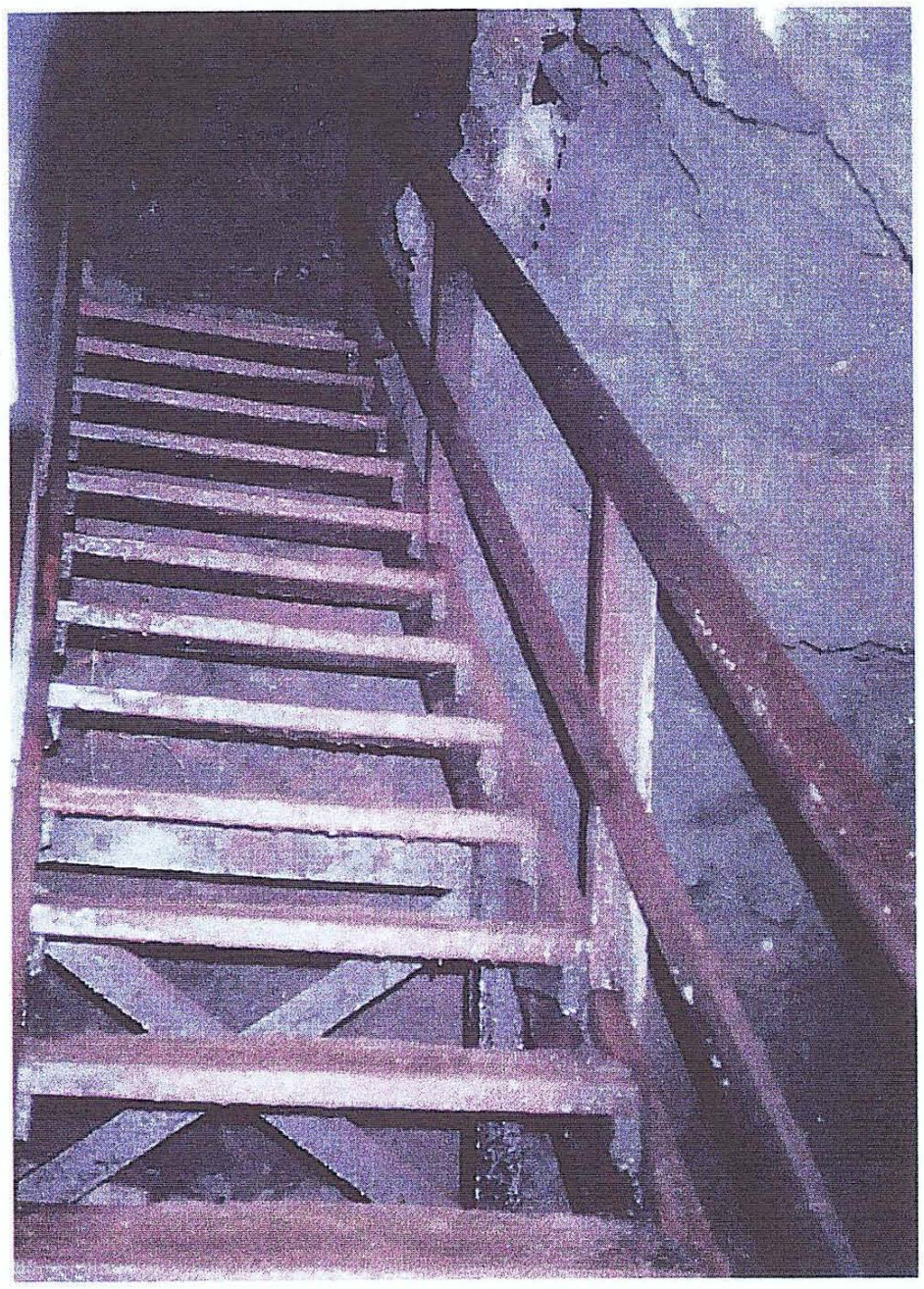
Waterfall to the right of Intake 31 now diverted back into the stream.

Looking out of the entrance to Intake 31.

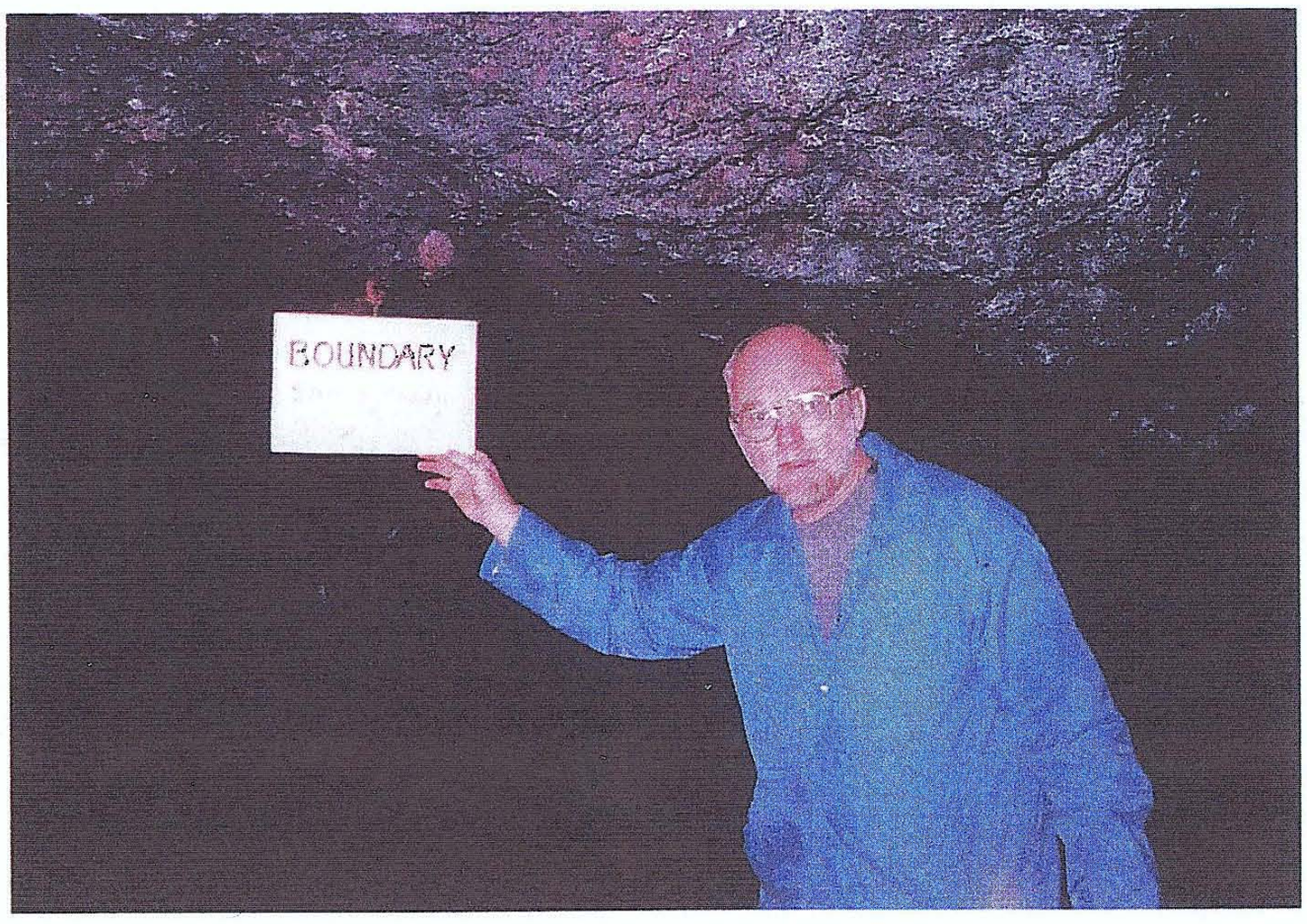
This photograph is taken at Intake 31. This is the monument erected to the Japanese construction workers. The Intake tunnel is to the left and the waterfall is to the right of this photo.

Water flowing back into the stream.

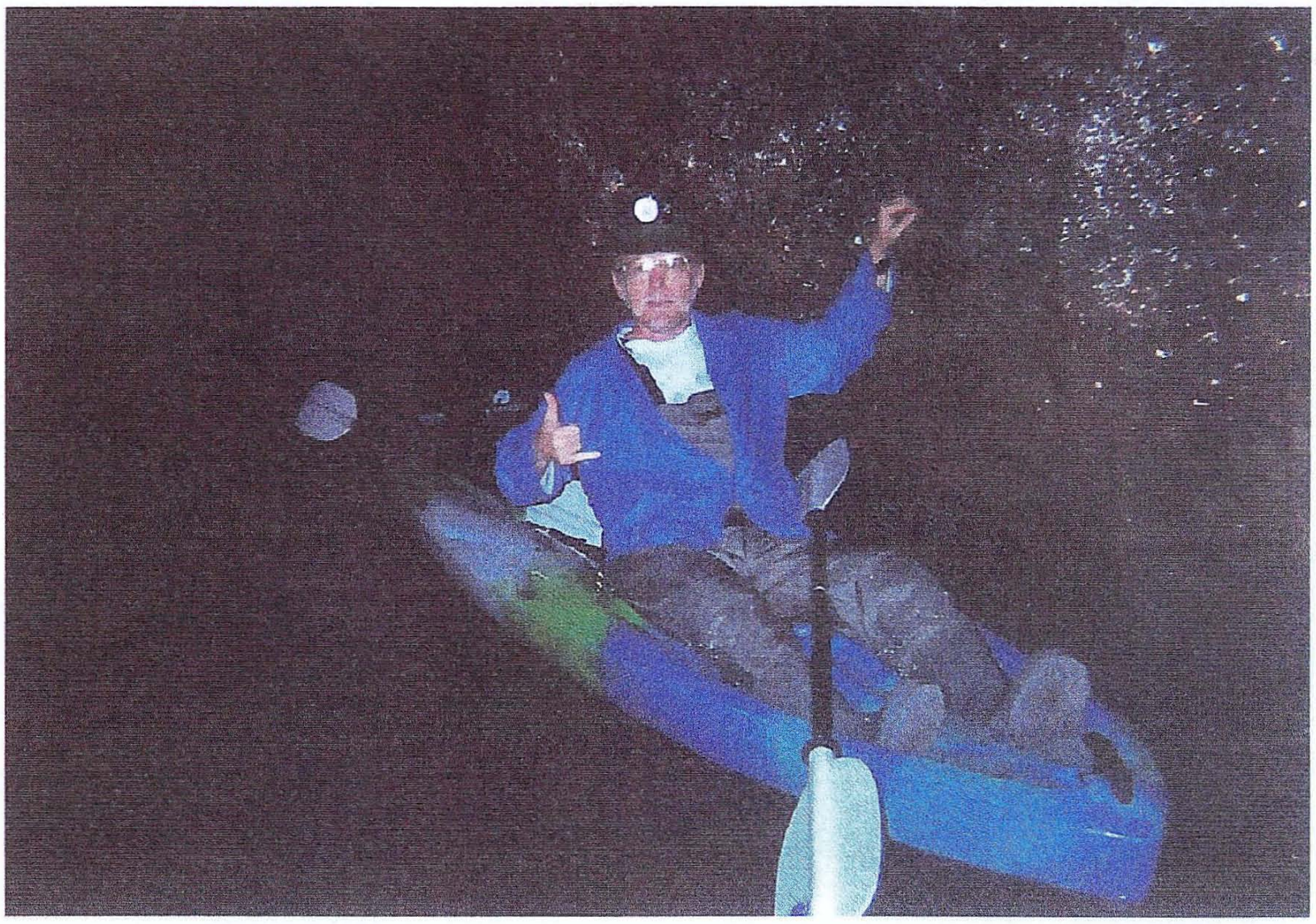
Looking up towards the Ko'olau mountains from the maintenance base camp, Waiahole valley.



Stairs leading down from the drainage tunnel to the main tunnel. This location is directly under the crest of the Ko'olau mountain. Drainage pump was located just to the right of the stairs.



Here I am at the boundary between Bishop Estate and State of Hawaii. This site is located at the bottom of the stairs in the above photograph.



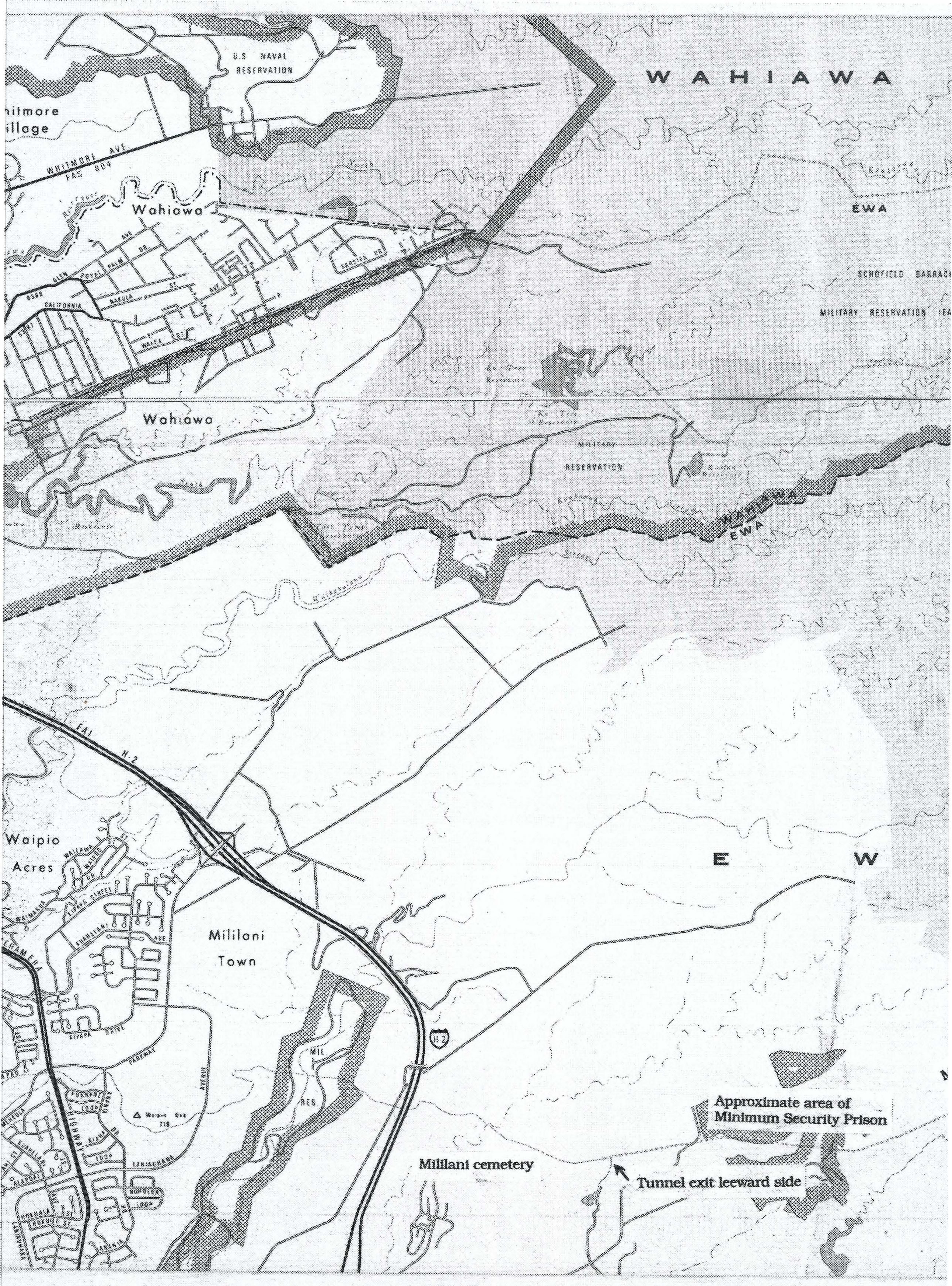
Kayaking the trans-Ko'olau tunnel; an experience of a lifetime.

Exiting at the South portal.

Maps

The first foldout map is a reduced reproduction of a Department of Land and Natural Resources (DLNR) map showing Central O'ahu and the Ko'olau mountains. The map shows the location of the tunnel and the labels I have inserted are for the convenience of the reader.

The next two maps are reduced reproductions of original 1916 Survey Maps showing the layout of the tunnels on the Windward side and the Leeward side of O'ahu. The original maps belong to the State of Hawaii, Agribusiness Development Corporation. Copies of the original maps are on file in the Hamilton Library Map Collection, University of Hawai'i. The original maps are 28 x 56 inches.


WAHIAWA
U.S NAVAL RESERVATION
WHITMORE AVE
FAS 804
Wahiawa
EWA
SCHOFIELD BARRACKS
MILITARY RESERVATION
Wahiawa
MILITARY RESERVATION
WAHIAWA
EWA
FAI
H-2
Waipio Acres
Mililani Town
E
W
Approximate area of Minimum Security Prison
Mililani cemetery
Tunnel exit leeward side

DISTRICT

RESERVE

Kahana Val

KOOLAULOA DISTRICT

Developmental tunnel

FOREST RESERVE

RANGE)

DISTRICT

DISTRICT

Developmental tunnel

KOOLAULOA DISTRICT

KOOLAULOA DISTRICT

Location of sign indicating the boundary between State of Hawaii land and Bishop Estate land

A

Main trans-Ko'olau tunnel

South portal entrance

Main trans-Ko'olau tunnel

EWA FOREST RESERVE

KOOLAUPOKO

DISTRICT

MILITARY RESERVATION

Waikāne Valley

Waikane

MILITARY RESERVATION

Location of monument to Japanese workers

Developmental tunnel

Waiahole

Connecting tunnels

Drainage tunnel entrance

Waiāhaole Valley

North portal entrance

WAIAHOLE FOREST RESERVE

KOOLAUPOKO

DISTRICT

KOOLAULOA DISTRICT

KOOLAUPOKO

KAMEHAMEHA HIGHWAY

Kahaluu

W A I A W A

W

Koolau Range

Tunnel A

Intake 34

Intake 35

Intake 36

Intake 37

Halona 2

Halona 1

Main Tunnel

Tunnel B

Measure Station

Elevation 752.60

Intake 32

Intake 31

Tunnel C

Pipeline

Elev. 480'

Pump Site

Trail

Waiahole Camp Site

Railroad

Elev. 250'-Weir

Intake 30

Intake 29

Intake 28

Tunnel No. 1

Waiahole Pipe Line Intake

L.C.A. 5936.

Waiahole Stream

Uwau Stream

Road

HAWAII

L.C.A. 8603.

KAPIKOAU

Makikiki Trig Sta.

GRANT 2874.

Waianu Stream

Gov. Line

WAIAHOLE

GRANT 4111

Waianu Stream

KAPU

Ditch

Approximate location Waianu Pipe Line

Road

Grant 2703. Ap. 3.

L.C.A. 7137.

Stream

Road

KAIPAPAU

L.C.A. 10237

L.C.A. 5806

L.C.A. 10456

L.C.A. 9830

L.C.A. 10239

L.C.A. 7650

L.C.A. 7655

L.C.A. 10238

Keolea

Lot 1

Lot 2

Lot 3

Lot 4

Lot 5

HOMESTEAD

Old Ditch

Old Government Road

Ditch

Waiahole Stream

Railroad

Old Ditch

Road

5000 N

5000 W

8000 N

8000 W

2000 N

2000 W

8000 S

2000 S

6000 E

4000 E

2000 E

4000 E

A I P I O

W A I A N

Koolau Range

Haauimakua
Elevation 2702

Unau Prospecting Tunnel

Intake 27

No 8

Intake 26.

Tunnel No 9

Intake 25.

Tunnel No 10

Intake 24

Maltane Prospecting Tunnel

Unau

Trail

GRANT 2702.

No 11

Ditchman No 3.

No 12

Intake 23.

Intake 22

Flood Gate

No 13

Intake 20.

Wezikane Prospecting Tunnel

No 14

Tunnel

Intake 19.

No 15

Intake 18

Trail

Kahana x.

Wayan Road

Elevation 458

A I K A N E

Waikeekee Stream

Waikane Wagon Road

Waikane Stream

Puu Ohulehule
Elevation 2260.'

H A K I P U U

6000 N

8000 N

10,000 N

12000 N

W A H I A W A

A E U K A

P U N A L U U

A H A N A

Koolau Range

Puu Kaua Prospecting Tunnel

Puu Pauao Peak

Intakes 1 & 2

Ditchman No. 1

Intake No. 1 Elevation 790.15

Intake 5

Intake 6

Intake 7

Intake 8

Intake 9

Intake 10

Intake 11

Intakes 18 A & 18

Ditchman No. 2

Intake 16

Intake 17

Tunnel No. 20

No. 19

No. 21

No. 22

No. 23

No. 24

No. 25

No. 26

No. 27

Elevation 450'

Elev 450'

Stream

Kahana Stream

Sta K & W

Koiele

N 14,000

N 16,000

N 18,000

N 20,000

W 4,000

W 6,000

W 8,000

W 10,000

W 12,000

W 14,000

W 16,000

MAP SHOWING

NORTH DIVISION

of

E WAIAHOLE WATER CO., LTD.

KOOLAULOA & KOOLAUPOKO, OAHU, T.H.

1916.

MAP BY F. KOELLING, SURVEYOR.

Scale: 100 500 1000 feet

H. HACKFELD & CO. LTD., AGENTS.

H. OLSTAD, SUPERINTENDENT.

Engineers on Construction:

H. K. Bishop - Chief, succeeded by Jorgen Jorgensen, - Contracting,
C. H. Kluegel - Inspecting & Consulting, J. M. Young - Consulting,
H. Olstad & F. Koelling - Division Engineers.

6000 E

7000 N

10000 E

14000 E

P

I

A

W

Road to Kipapa

Q.M. a S. KAIPIO A BASE

6000 E. from Kaipio A

Koa Tree

DITCH B

SIPHON B

Outlet Gate No 2

DITCH A

Japanese Planter

650' Contour

Pineapples.

Outlet Gate No 3. TUNNEL L.

Field Road

TUNNEL

Pineapples

Japanese Truck Garden

Main Road

Pineapples.

650' Contour

Pineapples.

Cane

Waiawa Reservoir

Water Supply Pipe

4200 S. from Kipapa Gulch

Waiawa-Kaipio

Boundary Line

CANE FIELDS of the

Field No 41.

OAHU SUGAR CO.

Railroad ditch

Office

Camp

Mess House

Cane

DITCH

Reservoir

Main Road

Oahu Sugar Co. Railroad to Cannery

Wood Pipe

Old Ditch

Reservoir Site.

Cane

Railroad to Mill

RESERVOIR

6000 S. from Waiawa Gulch

Plantation Road

Pipe Line Water from Pump 6

6000 S.

To Pump 6

Stream

PINEAPPLE FIELDS

of the

ARL CITY FRUIT CO.

18,000 E

22,000 E

Upper Forest Reserve Fence.

Sta Arthur R.

Ditchman No 2

Sta Ditch

TUNNEL G.

TUNNEL H.

TUNNEL I.

Gate

Outlet Gate No 2

Measure Station.

Ditchman No 1

Ditch Water from Kalloms Stream

Ahrens Ditch

Intake.

Ditch

Pineapples.

GULCH.

RAILROAD

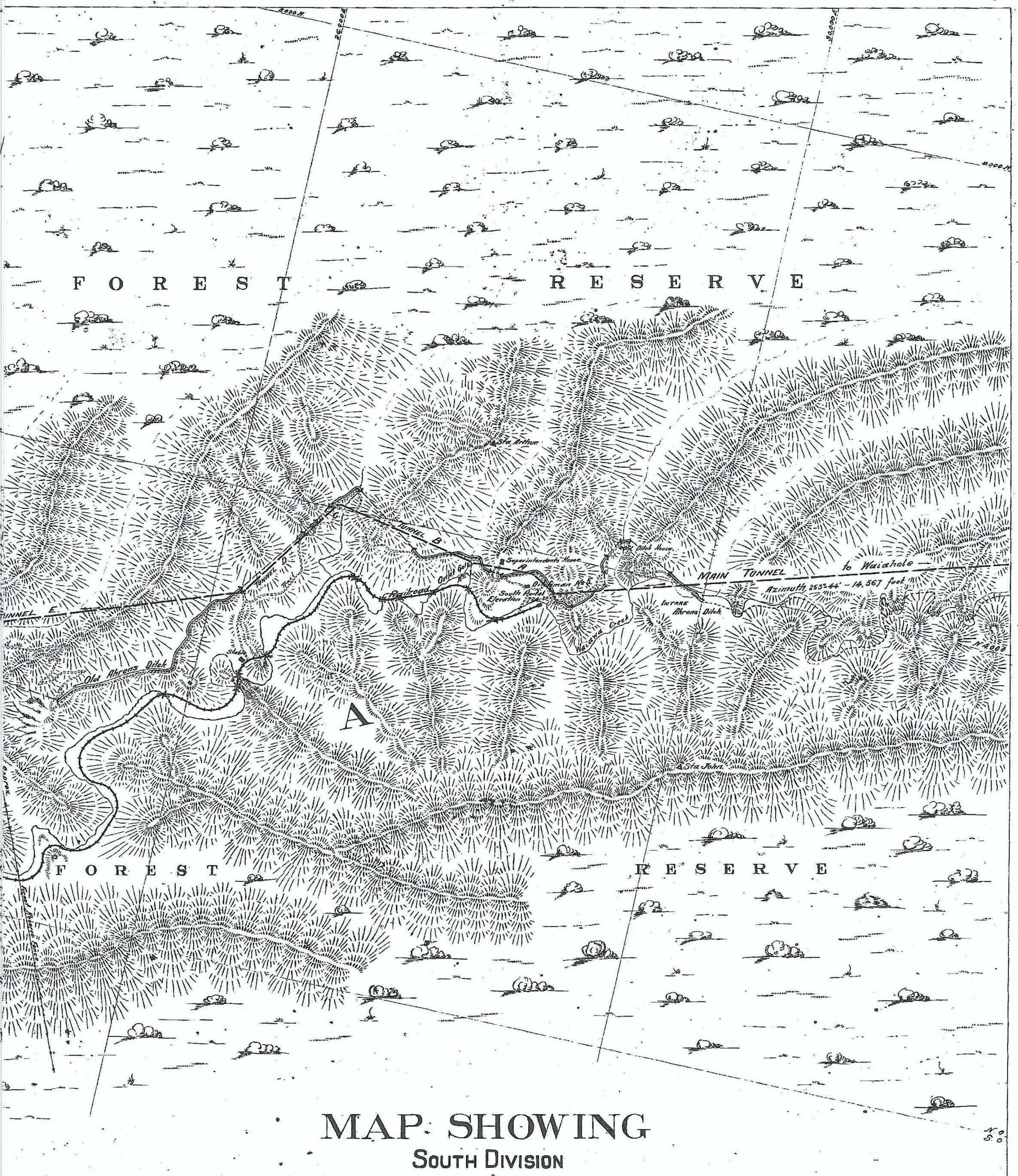
WAIAWA

TRUE NORTH

MAGNETIC

10°

20,000 E



MAP SHOWING

SOUTH DIVISION

of

THE WAIAHOLE WATER CO., LTD.

EWA, OAHU, T.H.

1916

MAP BY F. KOELLING, SURVEYOR.

Scale 100 0 1 2 3 4 5mi 1000 feet

H. HACKFELD & CO. LTD., AGENTS.

H. OLSTAD, SUPERINTENDENT.

Engineers on Construction:

H.K. Bishop - Chief, succeeded by Jorgen Jorgensen, - Contracting,
C.H. Kluegel - Inspecting & Consulting, J.M. Young - Consulting,
H. Olstad & F. Koelling - Division Engineers.